12-15-2008

The diffusion of innovative technologies among elementary and middle School teachers: Examining the relationship between access to social capital and level of technology adoption

John Patrick Bayerl

THE DIFFUSION OF INNOVATIVE TECHNOLOGIES AMONG ELEMENTARY AND MIDDLE SCHOOL TEACHERS: EXAMINING THE RELATIONSHIP BETWEEN ACCESS TO SOCIAL CAPITAL AND LEVEL OF TECHNOLOGY ADOPTION.

by

John Patrick Bayerl

Dissertation

Submitted to the College of Technology

Eastern Michigan University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Dissertation Committee:

Dr. John C. Dugger, PhD, Chair

Dr. Sema Kalaian, PhD

Dr. Erik Lokensgard, PhD

Dr. Yichun Xie, PhD

December 15, 2008

Ypsilanti, Michigan

Dedication

A work of this magnitude requires an immense investment of time, energy, and attention. This dissertation is dedicated to those who sacrificed so much to allow me to complete it, but most especially to my loving family, Amy and Brooke, who now get to spend the time with me that they so richly deserve.

Acknowledgments

This project would not have been possible without the help and support of many people. I am indebted to all of them and wish to formally acknowledge their contributions at this time.

My parents, Dr. John A. Bayerl and Gwendolyn Bayerl, taught me the importance of education. Their love and support have inspired and guided my pursuit of higher education.

Many teachers through the years conspired to teach me to write. My high school English teacher, Stanley Bidlack, taught me to love to write. I am forever grateful for his gift, as they made the countless rewrites of this document not only bearable, but also fun.

Thanks are due to the Monday Night Gripers—Sean, Brian, Russ, Don, Joe, and Tom. Your friendship, insight, and support were invaluable in facing the many obstacles I overcame. The bonds formed in our doctoral cohort were the most valuable asset I found in the entire program.

Dr. Polly Buchanan helped me navigate the growing pains of a new program. Her rock solid demeanor and sage advice saw me through many difficult times.

I am deeply indebted to my doctoral committee. Without the efforts of Dr. Sema Kalaian, I would not have been able to undertake the complex statistical analysis required by this project. Dr. Erik Lokensgard is a man of few words. However, his advice is always insightful, timely, and thought-provoking. I have known Dr. Yichun Xie for many years. His continued support and encouragement is greatly appreciated.

I am forever indebted to Dr. John C. Dugger, my dissertation advisor. He believed in me when no one else would. He saw the smallest hint of something worthwhile in my initial proposal and helped me develop my thinking into a meaningful investigation. This project, quite literally, would never have gotten off the ground without him. I will always value the continuing advice, support, and friendship he provided.

The contributions of my own social network can not be overlooked. The teachers, administrators, engineers, and secretaries I work with every day are among the hardest working, most dedicated professionals I have ever met.

My wife Amy and daughter Brooke sacrificed countless hours and most of their vacations over the last three years as I formulated my proposal, conducted my research, and wrote this document. Through it all, they remained positive and provided limitless unconditional encouragement. I really couldn't have done it without them.

Abstract

The purpose of this study was to examine the relationship between public school elementary and middle school teachers' access to social capital (the independent variable) and their level of adoption of innovative technologies (the dependent variable). The study was founded on both *diffusion of innovations* and *social network* theory.

Study participants were teachers from three schools, sharing two buildings in a single school district. The initial phase of the research involved informal interviews with key policy makers from each school, conducted for the purpose of identifying innovative technologies present at each study site. An existing survey instrument was modified and customized for each site to measure the study variables. Data were collected during a single sampling date at each site. A census of all teachers was attempted, and data were collected from 82% of possible respondents at the three schools.

The results of this phase of the study revealed that multiple innovative technologies were present at each site. Variation existed in both the level of adoption of innovative technologies as well as the teachers' access to social capital at each site. These results were consistent across subgroups based on gender, teaching assignment (academic or elective), and grade level (elementary or middle school). A strong, positive correlation was found between the study variables at all study sites and included nearly all the innovative technologies. An investigation of respondents' age, teaching experience and years assigned to the study site revealed no significant impacts on the dependent variable.

Based on these findings, it was concluded that teachers' access to social capital was the primary factor impacting the level of adoption of innovative technologies at each site.

Recommendations were presented including recognizing that innovative technologies exist within schools and that the necessary knowledge, help, and support teachers require in learning to use innovative technologies may be present within the existing social network present in schools.

Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction and Background

Technology and education: both provide the researcher nearly limitless possibilities for scientific inquiry. Due to the scope represented by these divergent subject areas, a prudent researcher wishing to study technology *and* education must strive to both narrowly focus and clearly define a specific area of interest. One promising area of inquiry that requires such focus and definition centers on teachers and their use of innovative technologies in the classroom.

One foundational work on the topic was the book *Teachers and Machines: The Classroom Use of Technology since 1920* by Larry Cuban (1986). This work chronicled the adoption of several key educational technologies in the 20th century, including film, radio, television, and classroom computers. Cuban's findings are often cited as evidence that such efforts ultimately prove unsuccessful and that classroom technologies are often underutilized by the American educational system (see Cuban, Kirkpatrick, & Peck, 2001; Frank, Zhao & Borman, 2004; Loveless, 1996; Zhao & Frank, 2003; Zhao, Pugh, Sheldon, & Byers, 2002). More recently, empirical research studies have provided support for these findings (Cuban, Kirkpatrick and Peck, 2001; Smerdon, Cronen, Lanahan, Anderson, Iannotti, and Angeles, 2000; United States Congress, Office of Technology Assessment (OTA), 1995; Wells & Lewis, 2005).

After acknowledging that this lag in technology adoption exists, current theory can be examined to provide insight into the problem. In general, problems that deal with the acquisition, adoption, and spread of technologies within organizations form a body of knowledge referred to as *diffusion of innovations theory.* In one seminal work from this body of knowledge, Rodgers (1995) defined *diffusion of innovations* as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). He also acknowledged that "getting a new idea adopted, even when it has obvious advantages, if often very difficult" (p. 1). Rodgers understood that some systematic process must act in determining whether a particular innovation is eventually adopted or rejected. His "*innovation - decision process"* (p. 63) attempted to model the steps by which an innovation progresses in stages from introduction to final implementation. A more complete discussion of Rodgers' model is included in Chapter 2 of this dissertation. Figure 1 presents a much simplified version of Rodgers' model.

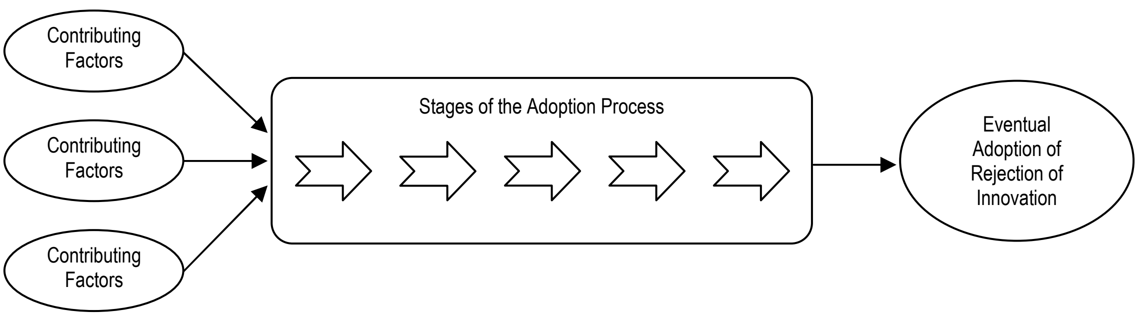


Figure 1. Simplified version of Rodgers' (1995) model of diffusion of innovations.

Rodgers not only provided an outline of the diffusion process, but also suggested that several factors contributed to that process. As such, his model serves as a sound theoretical foundation for further research on diffusion as it pertains to modern education. Professor Yong Zhao from Michigan State University, along with his colleagues and co-authors, has built upon this foundation in an attempt to create a broader understanding of the diffusion of innovations in education.

Zhao, Pugh, Sheldon, and Byers (2002) set out to "identify factors that facilitate or hinder teachers' use of innovative technology in their classroom" (p. 484). In identifying 11 such factors grouped into three categories, they were able to adapt Rodgers' model within the context of education. Building on this knowledge, Zhao and Cziko (2001) drew from the field of sociology and *perceptual control theory* (PCT) in order to examine these categories and suggested that characteristics of the individual teacher may be more significant than other factors in the adoption of innovative technologies in schools.

With a focus on characteristics of teachers identified as important, Frank, Zhao, and Borman (2004) set out to empirically model the diffusion process when they explored the adoption of computer technology in schools. To do so they drew heavily upon the field of *social network analysis* (see Grootaert, Narayan, Nyhan-Jones, & Woolcock, 2004; Van Duijn and Vermunt, 2006). Their analysis involved creating a comprehensive, complex model to explore the interrelation of factors contributing to the eventual adoption (or rejection) of these technologies (Figure 2).

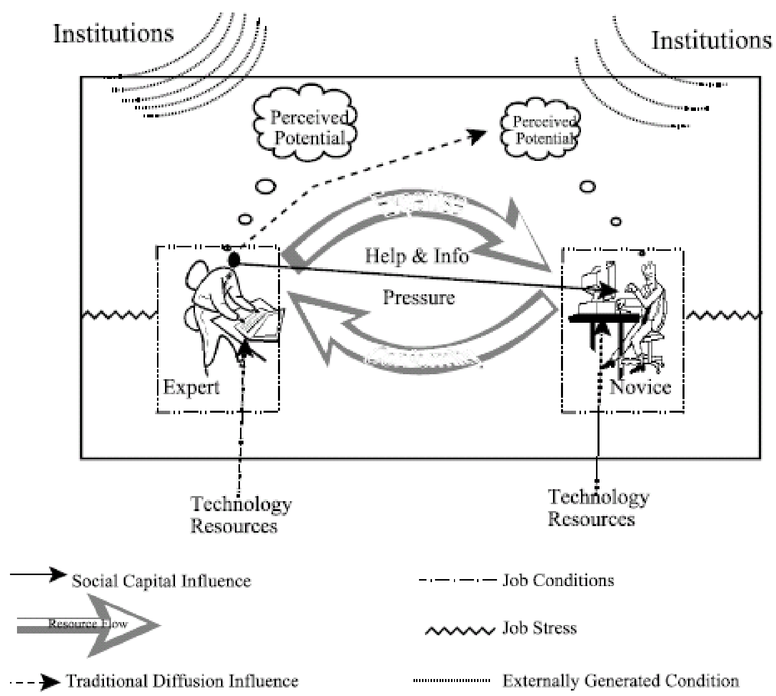


Figure 2. Diffusion of innovations in education (Zhao et al., 2002, p 6).

Emerging from their model were two significant factors used to predict the adoption of computers in schools: teacher expertise and access to social capital—both characteristics of individual teachers as predicted by Zhao and Cziko (2001).

Frank et al. defined social capital as teachers' "access to expertise through help and talk" (p.12) and also noted that "social capital is observably *manifest* when one actor allocates resources to another through interaction that is not formally mandated" (p. 13).

These authors acknowledged that their model was "somewhat exploratory in nature" (p. 9) and suggested that further research needed to be conducted in order to both more deeply examine these factors and identify methods that could be used by change agents when applying this knowledge towards an eventual solution to the problem. Arising from these conclusions is an implied need to empirically examine the relationship between teachers' access to social capital as it relates to the adoption of innovative technologies in schools.

Statement of the Problem

Educational technologies represent an enormous investment of scarce resources (Johnson, 2006). The problem is that, despite being given adequate access to new, innovative, and emerging educational technologies (U.S. Congress OTA, 1995; Wells & Lewis, 2006), teachers in the United States are slow to integrate these expensive innovations into their day-to-day practice (Cuban, 1986; Cuban et al., 2001).

Both *diffusion of innovations theory* (Rodgers, 1995) and *social network theory* (Frank, Zhao and Borman, 2004) have been used to explore the process of technology adoption in schools in an attempt to examine this problem. These and other studies (see

Zhao and Cziko, 2001; Zhao, Pugh, Sheldon, and Byers, 2002) have identified many potential factors that may impact the rate of adoption of new technologies. As these factors are studied, the most promising factor appears to be related to teachers' "access to social capital." Therefore this study focused on empirical exploration of the link between "access to social capital" and adoption of innovative technologies in schools as a potential means for addressing the observed lag in adoption of those technologies.

Justification and Significance

Much has been written about the need for a technically skilled workforce in the United States (Cutcliffe, 2000; Kleinman, 2000a; Pearson and Young, 2002; Pool, 1997; Yager, 2002). In *No Child Left Behind,* President George W. Bush (2001) wrote, "The Administration believes schools should use technology as a tool to improve academic achievement" (p. 22). According to the United States National Center for Education Statistics (Snyder, Tan and Hoffman, 2005) over 99% of all United States classrooms are currently equipped with classroom computers and access to the internet. Additionally, according to the United States Department of Education website (www.ed.gov), the 2008 budget for educational technology is $273.1 *billion*.

Based on this massive investment, one might assume that all teachers in the United States would not only have access to current technologies but also use them in their daily practice. It might be debated whether this investment is appropriate, the technologies chosen meet specific needs, or even if students benefit from such investment. However, these and other arguments are predicated on the assumption that these technologies are actually used by teachers. Unfortunately, as discussed previously, this is often not the case.

Therefore, research that seeks to more fully understand factors that contribute to the lag in adoption of innovative technologies and that might lead to a solution to the problem is not only academically relevant but also socially responsible and fiscally prudent.

Objective of the Research

As evidenced above, technology adoption in schools is a phenomenon influenced by many complex and inter-related factors (Frank et al., 2004; Rodgers, 1995; Zhao et al., 2002). This dissertation examined a single one of these factors—*teachers' access to social capital*—and explored whether or not a relationship existed between this factor and rate of adoption of innovative technologies by teachers in three independent school settings. Furthermore, this study examined several potential confounding variables and their effect on that relationship.

Research Questions

Based on the work done with social networks by Frank et al. (2004), one variable was identified that promised to shed more light on the problem of adoption of innovative technologies by teachers in schools. These authors purported that it is possible to define *adoption* of an innovative technology as "the degree to which teachers report using that technology" *(p. 11)*. *Social capital* was also defined as "the degree to which teachers report access to training, help and support in using those technologies from other teachers" (pp. 14-15). The potential relationship between social capital and adoption was the focus of the study.

The study examined the level of adoption of innovative technologies and access to social capital by teachers in two public school settings, as well as explored the effect of several potential confounding variables by seeking answers to the following questions:

1. What technologies that may be labeled as innovative existed in each study setting?
2. What was the current level of adoption of these innovative technologies by teachers in each study setting?
3. What was the level of access to social capital by the teachers in each study setting?
4. Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of adoption of innovative technologies?
5. Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of access to social capital?
6. Did a relationship exist between teachers' access to social capital and level of adoption of innovative technologies in the study setting?
7. Did a relationship exist between several potentially confounding variables (age, experience, on-site experience) and level adoption of innovative technology by teachers in the study setting?
8. What was the relationship between level of adoption of innovative technologies and access to social capital by teachers controlling for any confounding variables identified in questions 5-7 above?

Research Methodology Overview.

In order to seek answers to the research question, the researcher chose to pursue the *research* mode of inquiry as defined by Isaac and Michael (1995). A survey methodology (Fraenkel & Wallen, 2003; Isaac & Michael, 1995) was selected to collect data used to examine the statistical relationships between the research variables. The research proceeded in two phases: an instrument development phase and a data collection phase. Figure 3 presents a simple illustration of the research procedure. A complete and detailed schematic of the research is provided in Appendix A.

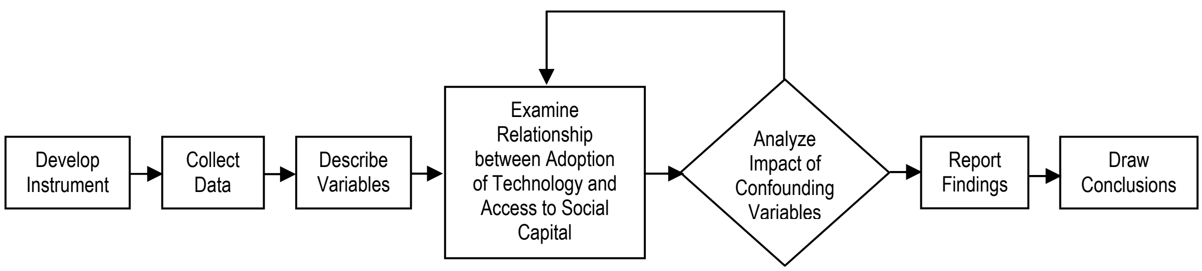


Figure 3. Research methods outline.

Population, Sample and Participants

The research focused on two middle / intermediate schools and a single elementary school located in a single school district, with the unit of observation and analysis limited to each individual school. That is to say, each school served as an independent sample, each with its own, unique population. A census of all teachers at each study site was attempted. However, some teachers chose not to participate for a variety of reasons. Data were collected via a survey questionnaire given at an after-school staff meeting routinely attended by most teachers.

Phase 1: Instrument Development and Customization

The need to include innovative technologies unique to each study site made it impossible to identify an existing survey instrument. Therefore a survey questionnaire was adapted from an existing instrument (Frank et al., 2002), customized to each study site and validated as part of the research.

In order to develop these custom instruments, key policy makers (administrators, lead teachers, media specialists, technicians, etc.) were interviewed at each site in order to identify several key innovative technologies present in each building. From this pool of information, specific innovative technologies identified were pared down to three or four items that served as the innovative technologies studied in each setting. Details of the interview process are included in Appendix B. A questionnaire was then developed and evaluated for content validity and readability by a panel of experts familiar with the research on technology and education and/or research methodologies (Appendix C). Based on feedback from the panel, the questionnaire was further modified until the finalized version was submitted to the University Human Subjects Review Committee (UHSRC) for final approval before commencing with data collection. Figure 4 is an overview of the instrument development process.

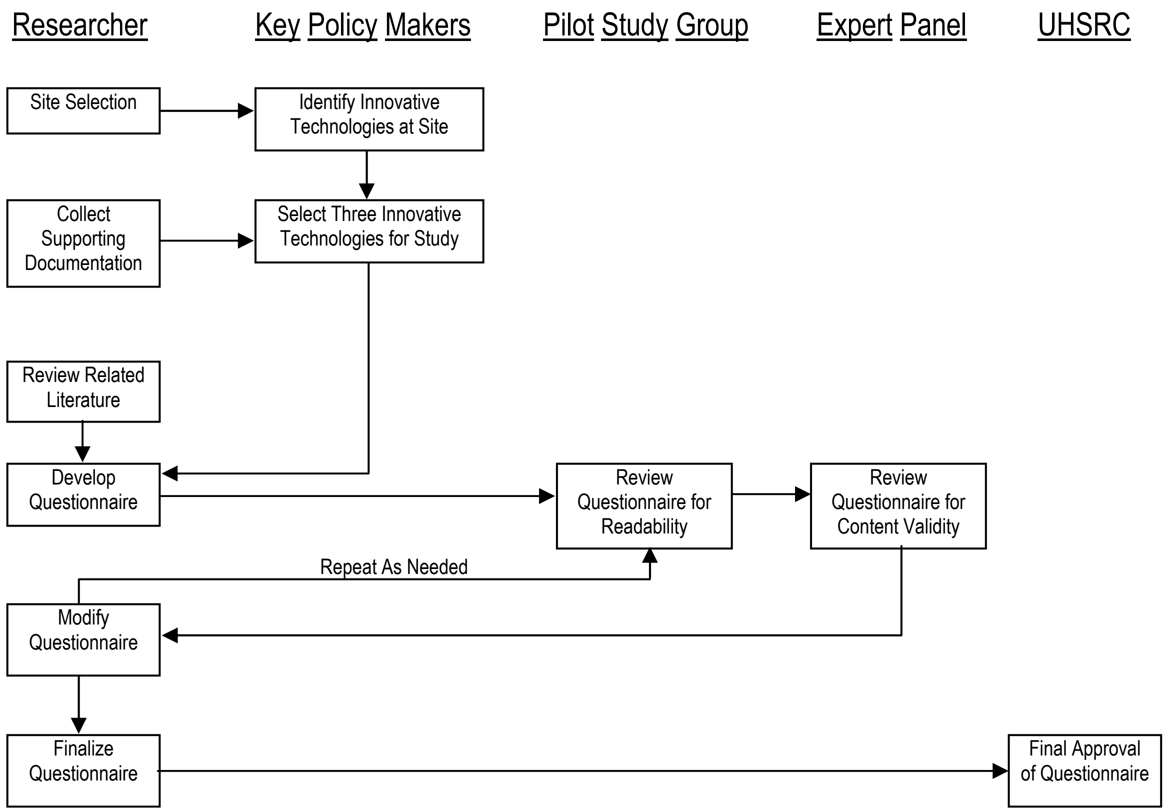


Figure 4. Overview of instrument development process.

Phase 2: Data Collection and Analysis

Information collected during the instrument development phase of the research included identifying innovative technologies present at each site (research question #1). Information collected via the survey questionnaire included data used to assess the level of adoption of innovative technologies by each teachers as well as their access to social capital (research questions #2, #3 and #6). Additionally, data were collected to examine these variables among several subgroups based on gender (male or female) and curriculum assignment (academic or elective classes; research questions #4 and #5). Last, data were collected in order to evaluate the potential effect of several possible mediating or confounding variables on the relationship between level of adoption and access to social capital (research questions # 7 and #8). These included the teachers' age, experience (total years teaching) and on-site experience (years teaching in the study setting).

A variety of statistical techniques and methods were used during the research study. Data were described using measures of central tendency, including mean, median, and mode. Variation was described using standard deviation. Furthermore, skewness, kurtosis and Shapiro-Wilks *W* were calculated to assess the normality of the variables. Finally, Chronbach's alpha (α) was calculated to assess the reliability of the custom instruments in measuring the study variables.

To detect differences between sub-groups, the non-parametric Mann-Whittney *U* test was was employed. In order to detect relationships between the study variables, Spearman's *rho* was used to evaluate a correlation coefficient (r_s). Last, the researcher intended to evaluate the effect of mediating variables using partial correlation or multiple regression techniques. However, since no significant confounding variables were identified during the study, no such analysis was undertaken.

Scope of the Study

Despite narrowing the focus of the study to level of adoption of innovative technologies and access to social support in using technology (social capital) by teachers in schools, the topic remained fairly broad. Therefore, the study was bound by a variety of factors, some imposed by the researcher for reasons of practicality and feasibility, others inherent to the study of phenomena in organizations run by complex social, political, and economic realities.

Delimitations

Every school in the study might have adopted different innovative technologies and might have a different interpretation of what constituted such a technology. Likewise, the complex social networks in each school might also have demonstrated significant differences between study sites. Therefore, the unit of analysis for this study was the teachers in three schools located in a single school district. Because of the potential differences in settings and innovative technologies, the unit of observation for the study was the individual teacher. As such, the data collected during the attempted census of each school represented a unique population, each with its own, unique results. While these samples could not be combined and the results could not be applied to the larger population, such a sampling plan did allow for comparison of results across multiple populations for the purpose of establishing some degree of practical transferability of results.

Because there could have been any number of technologies present in each building, which may or may not have been considered innovative, the study examined only a small selection of technologies accessible to all teachers and identified as innovative by key policy makers at the school. Detailed descriptions of the methods used to select these technologies are spelled out in the methodology section.

Because the study is focused on technology adoption by teachers, the study sampled only certified teachers and not teaching assistants, administrators, support personnel, substitute teachers, paraprofessionals, tutors, and so on.

In order to examine patterns of technology usage, the study evaluated such usage during the Fall semester of 2007 with data collection occurring during the beginning of

Spring semester 2008. This time frame represented approximately 90 days of instruction. Data collection occurred during mandatory, bi-weekly staff meetings. The time frame for data collection was the beginning of the Spring 2008 semester. Based on the school calendar, this represented a maximum of only three or four opportunities available for the purpose of data collection during the study.

Since district and building approval was necessary, as well as cooperation of administration and teachers at each study site, the study was limited to those schools that both volunteered to participate and were able to meet the scheduling demands required by the study. Last, due to practical considerations, data collection and analysis methods were selected based on what could reasonably be completed given the available resources, time, and participants at the time of the study.

Limitations.

Unfortunately, the diffusion of innovative technologies in schools remains a complex phenomenon. Therefore, multiple, confounding variables, both identifiable and hidden, emerged as the study progressed.

Because the study focused on individual teachers in the three schools, the statistical results were ultimately transferable only to that school and not statistically generalizable to the broader population of teachers and schools. However, repetition of the study in three schools was conducted in an attempt to reveal patterns of result and potentially provide a broader, practical validity to the study.

Since the technologies used in every school district are unique, no pre-existing instrument could be located that accurately assessed the unique technology usage in that district, nor the technology expertise or social capital characteristics of each staff.

Therefore, an instrument had to be developed and validated as part of the study. Such efforts may inherently suffer from issues of validity and reliability when compared to more established but less useful instrumentation.

Since schools have limited numbers of staff members, small sample sizes were to be expected. This problem was compounded when looking at sub-groups within teachers, limiting both the potential confounding variables that could be studied, and the statistical power of the findings.

Due to the use of survey methods and the specifics of the plan for data collection, data could only be collected at a single school at a time. Also, because the data collection was conducted at bi-weekly staff meetings, no more than two data collections could be completed per month. Outside obligations of the study facilities (staff meetings, professional development, achievement testing) also necessitated a narrowing of potential days that data collection could be conducted Finally, since the data collection was focused on the first semester of the 2007-2008 school year, the data collection had to be completed early in the second semester. Due to these scheduling constraints, only three sites were able to be evaluated.

Last, since the study was conducted in the school district in which the researcher was employed as a teacher (although in high school magnet program off-site from the other high schools), issues of researcher bias may cast doubt on the validity and interpretation of the results.

Terminology

In order to examine any relationship between levels of adoption of innovative technologies in education and teachers' access to social capital, precise definitions of several key terms are necessary. Doing so not only avoids confusion, but also guides the reader through the methodology used to seek answers to the research questions. Each of these terms was drawn from the literature on diffusion of innovation in the context of education. Descriptions of the specific technologies examined in the study are also included in this section.

Innovation

Rodgers (1995) defined an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 11). Such ideas, practices, and objects had to be identified at the study site in concert with policy makers (principals, media specialists, lead teachers, etc.) in order to select an appropriate technology or technologies for the study. Since a single technology may be intended for multiple purposes, many of these technologies were described in terms of their intended use. For instance, a PDA might be used for taking attendance, but also used by students for collection of lab data.

Diffusion of innovations

Rodgers (1995) defined *diffusion of innovations* as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). Since the study assumed that certain innovative technologies existed at each study site, diffusion of those innovative technologies was evidenced by the use of those technologies by teachers, who served as the members of the school social system. Furthermore, the social network at each study site was used to examine the level of adoption of innovative technologies through the communication of ideas by members of the social network.

Adoption of technology

Frank et al. (2004) defined adoption of innovative technologies "in terms of the number of occasions on which teachers used computers for five [educational purposes]" (p. 11). While these authors used computers as their innovative technology, this same definition served to assess the level of adoption of the innovative technologies identified during the instrument development process (discussed below).

Social Capital

Grootaert, Narayan, Nyhan-Jones and Woolcock (2004) defined *social capital* as "the resources (such as information, ideas, support) that individuals are able to procure by virtue of their relationships with other people" (p. 3). Frank et al. (2004) contributed, "Social capital is observably manifest when one actor allocates resources to another through interaction that is not formally mandated" (p. 13). They then operationalized this variable by asking each teacher to name whom they had received help using computers from, as well as to whom they had provided such assistance. Based upon Frank et al.'s methodology, access to social capital was measured by determining the number of occasions on which a participant interacted with other participants in terms of help received and help given.

Document Camera (ELMO)(Site 1, Technology 1)

These referred to a digital camera attached to the teachers' computers as peripheral devices. When coupled with an LCD projector, this technology allowed teachers to record and project papers, books, and other items onto the screen where they can easily be viewed by students. These devices are the digital analog to an overhead or opaque projector. At Site 1, they were available in every classroom.

Computer Labs (All Three Sites, Technology 2)

At Site 1, this term referred to both fixed (desktop) and mobile (laptop) computers, while at Sites 2 and 3, it referred only to the mobile (laptop) computers. In both cases, the instrument specifically referred to those computers that (a) were intended for student use (b) were available in class sets (30 computers) and/or (c) were able to be signed out by teachers to use with their classes.

Digital Cameras and Video Cameras (Site 1, Technology 3)

These referred to portable electronic devices capable of recording still images (digital cameras) or video (video cameras). In both cases, the media is stored in electronic form and can be downloaded to a computer to use in presentations, papers, and student projects. Teachers at Site 1 had access to several of each through the media center where they were available for use on a shared basis.

LCD Projectors (Site 1, Technology 4)

These referred to electronic devices capable of receiving a digital image from the teacher's computer and projecting it to a large screen. At Site 1, they are available in every room in conjunction with the document cameras. The survey instrument specified that teachers were to consider uses of the LCD projects not to include use with the document camera.

Promethean Boards (Site 2 and 3, Technology)

These are digital whiteboards interfaced to a teacher computer. They also include an integral LCD projector and student interface devices that allow students to "vote" or "answer test questions." Software included allows teachers to record and project their notes, survey and test students, and present interactive demonstrations to teachers.

Approximately half of the teachers at Site 2 had one in their room, and the remaining teachers (as well as those at Site 3) had access to several on a shared basis by checking them out of the media center.

Dukane DVD/VHS System (Site 2 and 3, Technology 2)

This was an integrated classroom video monitor, cable television, and media playback system available in all rooms at all study sites. It also includes the district emergency notification system, although this use was beyond the scope of the study. These monitors are used to play DVDs and video tapes in the classroom. However, this requires teachers to give the movie to the media specialist and then access the media though the monitor in their classroom using a remote control. Teachers may also access cable television, audio recordings, and closed circuit television broadcasts.

Chapter 2: Review of the Literature

E. F. Schumacher (1973) wrote that "No civilization, I am sure, has ever devoted more energy and resources to organized education, and if we believe nothing else, we certainly believe that education is, or should be, the key to everything" (p. 84). While it is impossible for a single person to comprehend the complexity of the educational system in its entirety, it is possible to work one's way down from broad generalizations of and about education to exacting examinations of the selected issues and specific topics contained within the literature. In such a manner it is possible to carve out a unique and well defined problem, suitable for further study.

Science, Technology, and Society

Before the nexus of technology and education can be examined, it is necessary to frame one's inquiry in the ongoing debate on the role science and technology play in our culture. The literature from the field of Science, Technology, and Society (STS) is filled with such discourse on the cultural role of technical literacy.

Cutcliffe (2000) outlined *constructivism* as one of the core concepts of STS with the following discussion:

> First and foremost STS assumes scientific and technological developments to be socially constructed phenomena. That is, science and technology, including the *content* of the former, are inherently human, and hence value-laden, activities which are always approached and hence understood through our senses. This does not deny the 'constraining' order of nature, but it does entail a recognition that our *understanding* of nature and our development of technology are socially mediated processes (p. 138).

Therefore, the researcher who desires to study some aspect of technology must also consider the contribution of social factors in framing their inquiry.

Bijker (2001) further observed that "We live in a technological culture—in a culture that is thoroughly influenced by modern society and technology" (p. 20) as well as "…all who live in this culture…have an obligation to try to *understand* the technological culture" (p. 21). In arguing the constructivist perspective of the debate, Bijker purported that such understanding was essential in a democratic society dependent on, and shaped by, the products of science and technology. Without this knowledge, he argued, citizens are not able to effectively participate in an informed manner when guiding technology policy.

Kleinman (2000a) added "…the boundary between the technical and non-technical—the scientific and the social—is not intrinsic or natural, but the outcome of sociohistorical [sic] processes" (p. 159). In doing so, he suggested that citizens of a democracy must obtain technical knowledge in order to integrate new technologies into our culture. In defining technology as "the knowledge and processes use to create and to operate artifacts," Pearson and Young (2002, p. 13) hinted at the important role education must play in producing such a technologically literate populace.

Schumacher (1973) spoke to the intrinsic human desire for education when he wrote:

> When people ask for education they normally mean something more than mere training, something more than mere knowledge of facts, and something more than a mere diversion. Maybe they cannot themselves formulate precisely what they

> are looking for; but I think what they are really looking for is for ideas that would make the world, and their own lives, intelligible to them (p. 75).

To Schumacher it was this drive to understand the world that gave meaning and relevance to a person's existence and therefore provided both the ethical, morale, and (Schumacher would argue) economic mandate for governing bodies to encourage this pursuit among their citizenry.

McRobie (1981), a disciple of Schumacher and co-founder of the Intermediate Technology Group (ITG), labored to put these principles into action, as evidenced by his belief:

> Can we not recognize that there is really no other choice than to create a new technology and economic system designed to serve not a continuously escalating spiral of production and consumption, but to serve people by enabling them to become more productive? (p. 191)

Based upon this philosophical foundation, writers in the STS literature argue that the ultimate role of education in our society is to produce a citizenry possessing the requisite knowledge and skills required to fully participate in the increasingly techno-scientific culture in which we all must live.

The Need for Technical Literacy

Volti (2002) suggested that in our modern, evolving workplace "…many [persons] will be engaged in work activities that are unknown today" (p. 76). Volti also observed that, while the manufacturing industry has largely switched to technology-intensive practices, those same industries have not produced adequate numbers of high-skilled, high-paying jobs. Pearson and Young (2002) referred to both United States

Department of Labor (DOL) and Department of Defense (DOD) studies that point to shortcomings in technological skills in diverse industries including medical, education, agriculture, the military, and certain “high-tech” industries. They also pointedly noted that the U.S. is importing workers in these industries from other countries.

While the need for skilled workers certainly exists, Volti pointed out that the need for technological literacy extends beyond the workplace. It may also be argued that a technologically literate populace is an absolute requirement if there is to be democratic participation in scientific and technology policy. Kleinman (2002b) provided many examples of such participation ranging from AIDS activism to spreading agricultural knowledge and even to nuclear facility policy decision making—a belief chronicled in detail by Pool (1997).

Certainly, participants in the STS debate see the need for a technically savvy citizenry and the role of our educational system in producing graduates with the necessary technical skills and knowledge required to participate in our culture. The question remains open to debate as to whether our schools are accomplishing this goal or not.

Historical Perspective on Technology and Education

Perhaps the best known treatise on the state of our modern education system was *A Nation at Risk* (The National Commission on Excellence in Education, 1983). This brief and poignant report suggested that the United States education system was failing to produce graduates with the skills and knowledge necessary to compete in an increasingly global political and economic system. The report ranked United States students near the bottom among developed nations in terms of the academic achievement of its high school graduates.

According to DuFour and Eaker (1998), *A Nation at Risk* helped to launch an era of massive educational reform in the United States, culminating with the current *No Child Left Behind (NCLB)* legislation (see Bush, 2001; United States Congress, 2001). Because of the increased accountability placed upon schools by NCLB, many school districts have adopted strategic plans to meet the mandates of reform legislation (Nutt & Backoff, 1992). Many of these plans included provisions for the acquisition of educational technologies (Lancaster & Lancaster, 2000; Rai, 2004; Shibley, 2001). Kollie (2005) illustrated several of the potential benefits that these technologies offered, including "improved education, productivity and efficiency for financial savings" (p. 25).

Adoption of Technologies in Schools

One foundational work on teachers' use of technology in schools was *Teachers and Machines: The Classroom Use of Technology since 1920* by Larry Cuban (1986). The work is often cited as evidence that classroom technologies are underutilized in the American educational system (see Cuban, Kirkpatrick, & Peck, 1001; Frank, Zhao & Borman, 2004; Loveless, 1996; Zhao & Frank, 2003; Zhao, Pugh, Sheldon, & Byers, 2002). Cuban's (1986) research method involved:

> …completing a review of the academic research and popular literature on the adoption, use, and influence of classroom media since 1920. This review included controlled experiments, impressionistic accounts, surveys, interviews, project reports, ethnographs, and combinations of these approaches. In examining

> this diverse body of formal and informal research, [Cuban] avoided meta-analysis of comparable studies and concentrated on making sense of conclusions (p. 115).

While not strictly an empirical study, Cuban (1986) did offer some observations backed with numerous examples from his historical research. When one examines these examples, a pattern begins to emerge. He cited one study on the use of film in the high school classrooms showing "23 percent of teachers reporting 'Frequent' use, 33% 'Occasional' and 19% 'Never'" (p. 16.). Referring to the use of radio in the classroom, the results were no better, with the author citing a survey showing that only "3% of rural schools, 18% or urban schools, 8% of elementary schools and 5% of secondary schools used the radio 'Regularly'" (p. 23). The use of television in the classroom also appears to have followed this pattern, with Cuban (1986) citing yet another survey showing that "13% of elementary, 43% or junior-high, and 60% of high-school teachers reported *no* use [of television] whatsoever in 1981" (p. 39). While Cuban (1986) does include examples of successful technology adoption, he nevertheless concluded: "Such noteworthy praise…only have underscored how rarely teachers have used machines in their classrooms since the 1920s" (p. 51). While Cuban's (1986) findings are arguably based upon his interpretation of disjointed data sometimes taken out of context, recent quantitative research studies appear to verify his assertions by showing that this lag or failure in technology adoption does indeed exist.

In another widely cited study of teachers' use of technology, the United States Congress, Office of Technology Assessment (OTA; 1995) reported that "despite over a decade of investment in educational hardware and software, relatively few of the nation's 2.8 million teachers use technology in their teaching" (p. iii). It should be noted that this study and many of those that followed focus on the use of computers and the internet in schools when discussing the adoption of technology.

Smerdon, Cronen, Lanahan, Anderson, Iannotti, and Angeles (2000) of the National Center for Education Statistics analyzed three national databases. These data sources contained the results of various surveys given to both public and private school K-12 teachers. The results of their analysis revealed that while most schools (99%) provided access to technology for teachers and students, less than one-third of teachers reported feeling well prepared to use technology. Cuban, Kirkpatrick, and Peck (2001) examined two "high tech" high schools in California. Only four of the 13 teachers studied had incorporated the teacher and student computers or internet technologies provided in their building into their teaching practice.

Most recently, Wells and Lewis (2006) of the National Center for Education Statistics (NCES) drew upon the Fast Response Survey System (FRSS) to examine the use of the Internet in U.S. Public Schools between 1994 and 2005. According to the authors, this database represented the most current and up-to-data data set available at the time of the study. The study used a statistically representative sample of 1205 public schools to generate statistics for the 85,000 primary and secondary public schools in the United States. Chief among the study's conclusions was "by fall 2005, nearly 100 percent of public schools in the United States had access to the Internet" (p. 4).

Unfortunately, this did not translate into 100% usage of these technologies by teachers. Specifically, the study's authors found that "83 percent of public schools with Internet access indicated that their school or school district had offered professional development to teachers in their school on how to integrate the use of the Internet into the curriculum" (p. 10) and of these schools only "34 percent of the schools that offered professional development in 2005 had from 1 to 25 percent of their teachers attending such professional development …16 percent of the schools had 26 to 50 percent of their teachers, 13 percent of the schools had 51 to 75 percent of their teachers, and 36 percent of the schools had 76 percent or more of their teachers attending professional development" (p. 10).

Similarly, Wells and Lewis (2006, p. 10) reported that not all schools with internet access used them for instructional purposes, listing the reported usage with the percentage of schools reporting such usage including providing lesson planning (89%), providing assessment results to teachers (87%), providing digital content to the classroom (87%), professional development (51%), and distance learning (32%).

Consistent among these studies is the fact that, while teachers have adequate access to innovative technologies in their classrooms, those same technologies are often not fully utilized. This supposition served as the problem for this research study. In order to more clearly illustrate the theoretical foundations and the existing research used to focus the inquiry into this problem, a series of graphic schematics are presented to guide the reader. These are not, however, classical research models showing variables and their interactions. Figure 5 is a basic illustration showing the existing relationship between teachers' access to technologies and their implementation of those technologies

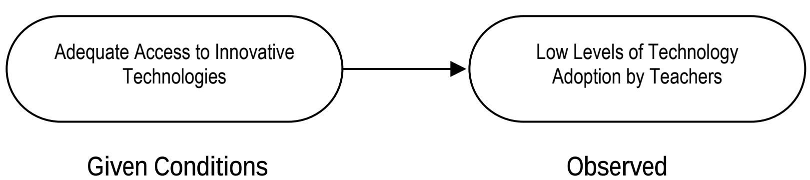


*Figure 5***.** Initial model of the research problem.

Implicit in this statement is the idea that existing efforts to address the problem are ineffective, as evidenced by the failure of those efforts to increase the level of usage of technological innovations. Figure 6 incorporates this idea into the model.

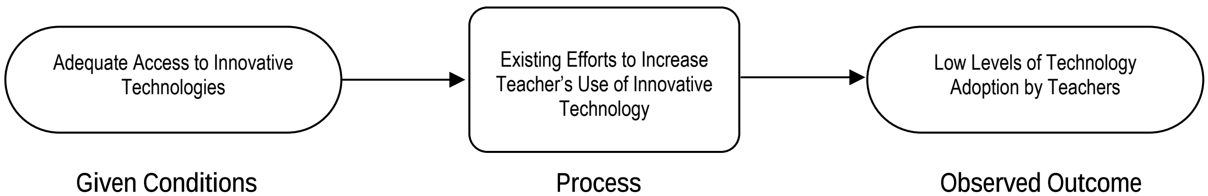


*Figure 6***.** Model showing efforts are not effective.

Theoretical Foundations I: Diffusion of Innovations Theory

To begin to examine this technology adoption problem, one should delve into the literature on *diffusion of innovation*s, which attempts to explain, among other things, the process by which technological innovations are adopted by groups, organizations and other social entities. In perhaps the seminal work on the topic, Rodgers (1995) defined *diffusion of innovations* as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 5). He proposed a model he called the *innovation-decision process*, which can be used to explore and explain the implementation of innovative technologies in the context of organizations (Figure 7).

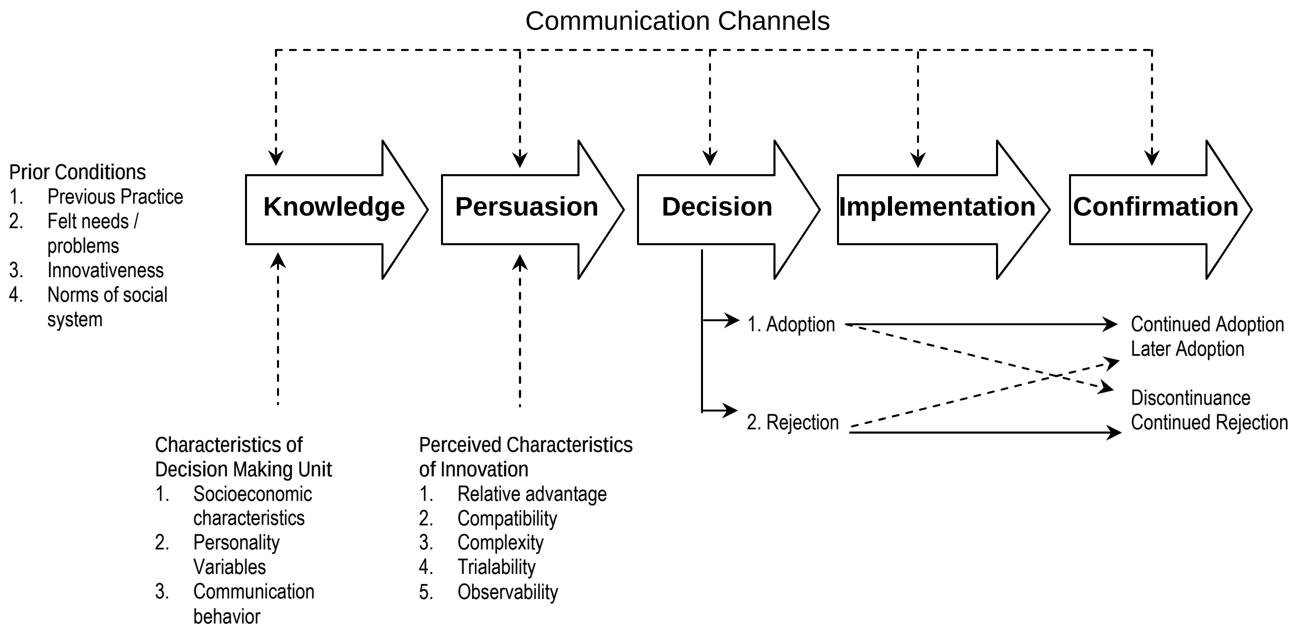


Figure 7. Innovation-decision process (Rodgers, 1995, p. 163).

In this model, Rodgers identified several salient factors that he felt contributed to the decision process, including characteristics of the decision makers themselves, characteristics of the innovation and characteristics of the workplace. It is important to note that each of these is further subdivided into contributory factors, all of which interact with one another as they influence the eventual adoption of rejection of an innovation. Figure 8 places Rodgers' innovation-decision process into the schematic of the problem. Notice that Rodgers not only provided a model of the process by which technology adoption decisions are made but also suggests that several factors contribute to that process.

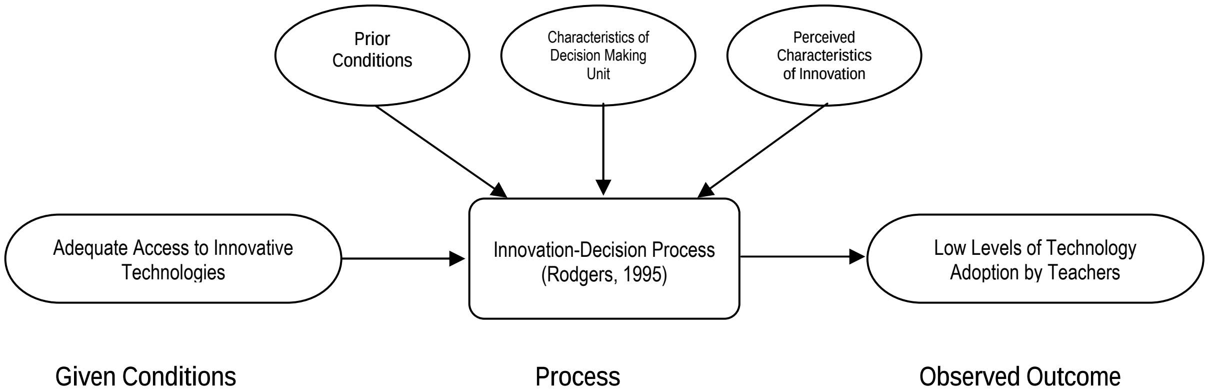


Figure 8. Rodgers' (1995) model used to illustrate implementation process.

While such a model may be useful in examining technology adoption by any number of organizations, it is not specific to the context of education. Therefore, further refinement of the adoption process model is required.

Diffusion of Innovations in Education

Professor Yong Zhao of Michigan State University has drawn heavily from Rodgers in his examination of technology adoption in the context of public schools. While Rodgers' work was primarily theoretical, Zhao's efforts have begun to empirically examine diffusion of educational innovations.

Zhao, Pugh, Sheldon, and Byers (2002) set out to "identify factors that facilitate or hinder teachers' use of innovative technology in their classroom" (p. 484) and identified eleven salient factors that contributed to the successful integration of a technological innovation by teachers. These factors were further loosely grouped into three domains—the innovator (teachers), the innovation (technology) and the context (the classroom/school; Table 1). Note that these factors are strikingly similar to those characteristics mentioned by Rodgers.

Table 1
Factors Influencing the Adoption of Technologies in Schools (adapted from Zhao et al., 2002, p. 490)

Domain	Factors
The Innovator (Teachers)	▪ Knowledge of technology and its enabling conditions. ▪ Pedagogy-technology compatibility ▪ Knowledge of the organizational and social culture of the school.
The Innovation (Technology)	▪ Distance from school culture. ▪ Distance from available resources. ▪ Distance from innovator's current practices.
The Context (Classroom/School)	▪ Technological infrastructure. ▪ Human infrastructure. ▪ Organizational Culture.

From these findings, Zhao et al. (2002) set forth a preliminary model that illustrated how these factors combine to influence the adoption of technology in schools. Figure 9 is an illustration of their model.

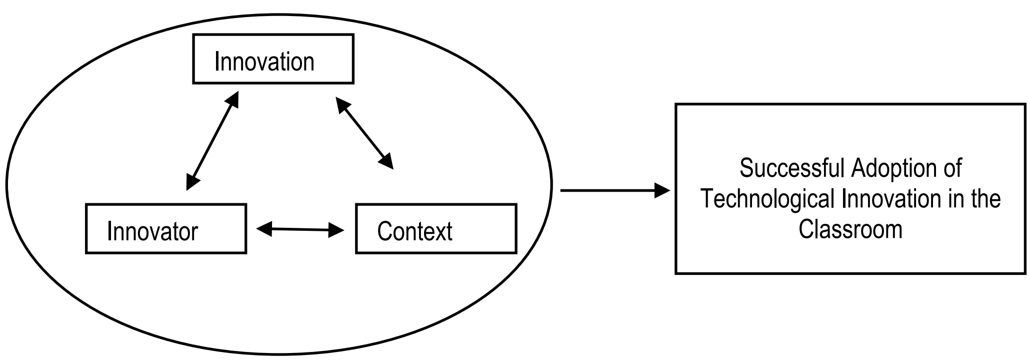


Figure 9. Model of innovation implementation in schools. (Zhao et al., 2002).

Combining the work of Zhao et al. (2002) and Rodgers (1995) yields a workable model to explain the technology adoption process in the public education settings. Figure

10 shows a further development of the schematic showing the adoption of technology innovations in public education using the innovation-decision process from Rodgers (1995) as well as factors influencing the technology adoption process from Zhao et al. (2002).

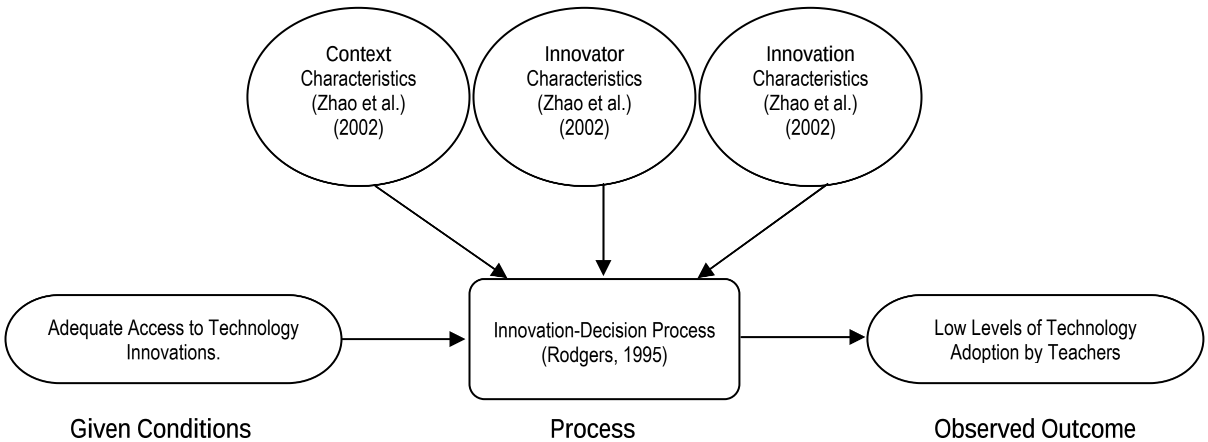


Figure 10. Model of innovative technology adoption (Rodgers, 1995; Zhao et al., 2002).

Once the factors influencing the innovative technology adoption process had been identified, Zhao set out to examine the interaction of these factors in an attempt to more fully understand the process by which they affect the adoption of innovations in a public school setting. Zhao and Cziko (2001) drew from the field of sociology and p*erceptual control theory* (PCT) in an attempt to understand why teachers might choose not to adopt a technology. From this framework the authors suggested that three conditions must be met in order to ensure the use of technologies by teachers: adopting a new technology must contribute to maintaining a higher-level goal; it must not interfere with existing higher-level goals; and the teachers must believe that they possess the necessary skills and resources needed to adopt the technology. Without meeting these criteria, Zhao and

Cziko maintained: "It is unlikely that [the teacher] will use the technology in [his/her] teaching" (p. 21). This study suggested that characteristics of the individual may be more important to the adoption process than those of the innovation or the school setting

Such a claim is likewise supported by the work of Schön (1983) and his concept of the *reflective practitioner*, in which he contended that teaching, like many other professions, has become so technical and complex that the only persons capable of truly understanding the teaching profession and making meaningful changes to the practice of teaching are the teachers themselves.

However, characteristics of the teachers should not be viewed as the only significant contributor to implementation of innovations. Zhao et al. (2002) also cautioned that the environment in which teachers work can not be ignored. According to Towle (1989), ecology is "the study of relationships between organisms and their environment" (p. 762).

Zhao and Frank (2003) used an example from the science of ecology—the invasion of the Great Lakes by zebra mussels—as a metaphor for the implementation of technology in schools. While the authors cautioned that their work was simply a metaphor, they concluded that: "The ecological model took us beyond simply identifying and correlating factors and focused our attention on interactions, activities, processes, and practices" (p. 833). This certainly supported the supposition that further research must focus on teachers and their interactions both with each other in the context of the school as a workplace.

Drawing from Zhao's work, it is possible to modify the model of innovative technology adoption in schools to reflect these ideas. Beginning with Rodgers' model of the innovation-decision process, Zhao concluded that several factors all contribute to the overall process that determines whether or not a particular innovation is eventually implemented. Furthermore, Zhao illustrated that characteristics of individual teachers may be more important that other factors in this process. Figure 11 illustrates such a hybrid model.

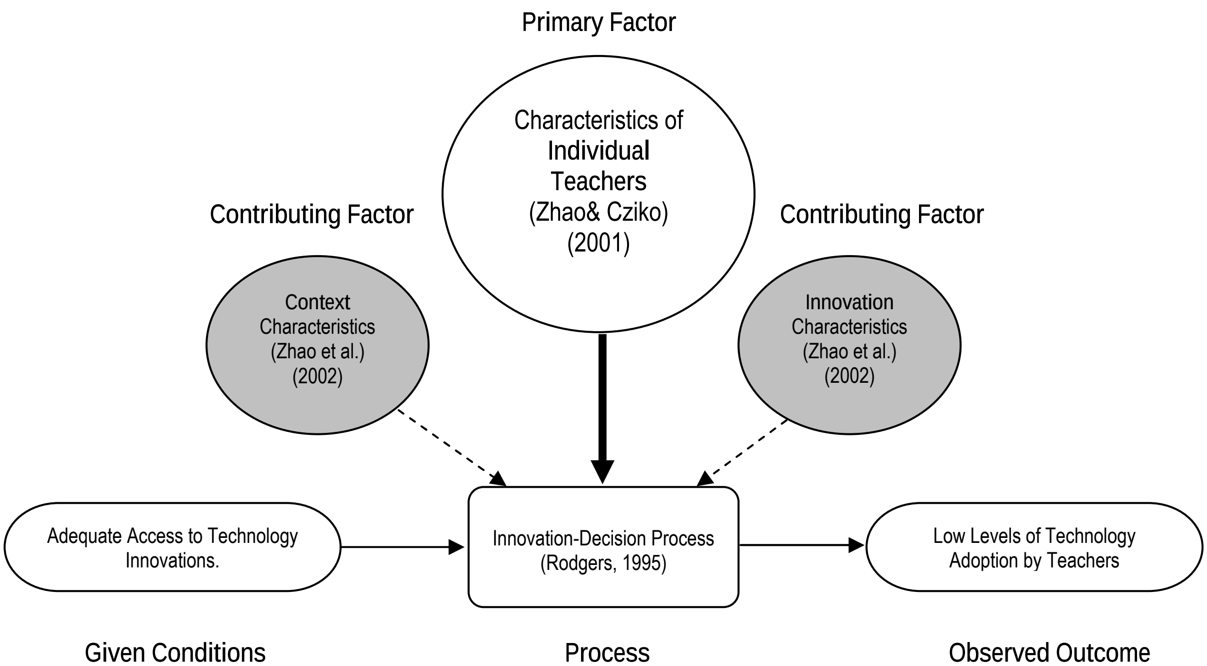


Figure 11. Characteristics of teachers as the primary factor in implementation.

Drawing on these findings, it is now possible to postulate an approach to the empirical examination of the characteristics of individual teachers in the context of their workplace and attempt to determine the impact these factors have on the adoption of innovations in schools. However, to do so, one must first examine the literature surrounding the concepts of *social capital* and *social network analysis*.

Theoretical Foundations II: Social Capital and Social Network Theory

In order to understand social phenomenon, it is necessary to study not only the individual participants, but also their interactions. Such a method is referred to as social network analysis. In a brief overview of this interdisciplinary field, Van Duijn and Vermunt (2006) suggest that:

> The large interest in social networks can be understood in view of the important theoretical and intuitively appealing research questions connected with social networks and the challenging methodological problems associated with the collection and analysis of social network data. This fruitful combination of content and methodology has stimulated lots of research in the past…both aspects of social network analysis involve theoretical as well as empirical problems, which makes the challenge even greater and the research more rewarding (p. 2).

According to the authors, social network analysis seeks to describe, visualize, and model the interactions (ties) between participants (nodes). These connections lead to the development of complex statistical models aimed at empirically quantifying the variables involved in the research questions.

One variable useful in applying social network analysis to technology implementation in schools is *social capital* as described by Grootaert, Narayan, Nyhan-Jones, and Woolcock (2004). These authors describe two definitions of social capital, the first being more applicable to the question at hand:

> [Social capital]…refers to the resources (such as information, ideas, support) that individuals are able to procure by virtue of their relationships with other people. These resources ('capital') are 'social' in that they are only accessible in and

> through these relationships, unlike physical (tools, technology) or human (education, skills) capital, for example, which are essentially the property of individuals. The structure of a given network—who interacts with whom, how frequently, and on what terms—thus has a major bearing on the flow of resources through that network (p. 3).

Armed with these definitions of social capital and social network analysis, it is possible to further develop the model of technology implementation in schools to account for the effects of teacher social interaction in the context of the workplace.

Social Networks and Diffusion of Innovations in Education

Frank, Zhao, and Borman (2004) explored the implementation of computer technology in schools. Their focus was on schools as social organizations, building upon Rodgers' theories of diffusion of innovation to include the effect of social pressure on influencing individuals' decisions about technology implementation. They examined *social capital* as the amount of influence one teacher has on another's use of technology, which manifested itself as opportunities to access help from or communicate directly with other teachers in order to problem solve, as well as peer pressure to use innovative technologies.

The researchers set out to examine the effect of social capital compared to other, traditional diffusion of innovation factors (see Rodgers, 1995). On his website (http://www.msu.edu/ ~kenfrank/index.htm), Dr. Frank provided the instruments and protocols that he used to quantitatively assess the level of technology implementation in a school setting, as well as gather data on the impact of social capital and a variety of more traditional contributing factors that may influence that implementation. It is important to note that Dr. Frank's purpose was to examine the use of classroom technology by teachers using a gestalt approach. By examining all contributory factors in detail, he was attempting to model the entirety of the phenomenon as a sum of its pieces.

Using social network theory to guide the general linear model (ANOVA and regression), Frank et al. (2004) were able to further evaluate these factors and examine how they interact as predictors of technology implementation by teachers. A brief summary of their regression model is presented in Table 2.

Table 2

Results of Frank et al. (2004) Regression Model

Independent Variable	Standardized Coefficient	Statistical Significance
Own Expertise	.32	$p \leq .001$
Access to expertise through help and talk (social capital)	.21	$p \leq .01$
Perceived adequacy of physical resources (traditional diffusion)	.19	$p \leq .01$
Perceived potential of computers for teachers' use (traditional diffusion)	.18	$p \leq .05$
Perceived social pressure to use computers (social capital)	.16	$p \leq .05$
Class size (job conditions)	-.12	$p \leq .05$
Perceived changes in emphasis on standardized tests (job stress)	-.16	$p \leq .05$

Frank et al. (2004) reported that their regression model had a high degree of explanatory power ($R^2 = .42$). Furthermore, using a longitudinal measurement of these factors (comparing these results to a preliminary study conducted the year before), the researchers examined the changes in R^2 values between social capital variables ($\Delta R^2 = .10$) and traditional diffusion variables ($\Delta R^2 = .08$). From these results, the researchers concluded that, while moderate, these factors “need not have dominating effects to be an important force for the implementation of innovations” (p. 162).

Reflecting on the work of Zhao and Cziko (2001), in which characteristics of the teacher are the primary factors influencing the adoption of technology, it is possible to postulate a more complete model of technology adoption in education. In this model, personal expertise and social capital factors (themselves characteristics of the individual teacher) provide the primary force driving the innovation adoption process. Such a model is presented in Figure 12.

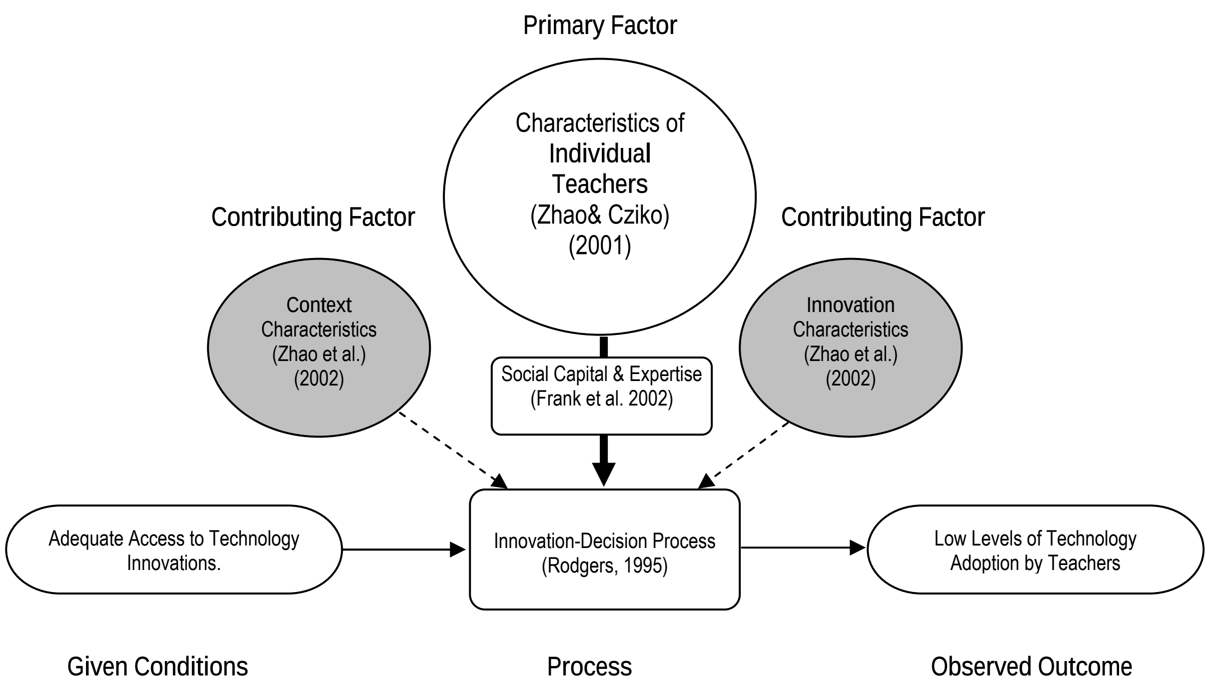


Figure 12: Social capital and expertise as significant variables.

Beginning with the simple thesis that Rodgers’ (1995) *innovation-decision process* serves to bridge the gap between technology acquisition and technology adoption, researchers have begun to expand Rodgers’ model through the empirical examination of factors that may influence that process. By singling out characteristics of individual teachers (Zhao & Cziko, 2001) as the primary factor, it is possible to begin to look at significant variables with which to study that process. Frank, et al. (2004) provided two such potential variables in determining that teacher's expertise as well as access to training, help, and support from each other (social capital) are statistically significant contributors to the adoption of technology in education.

In their discussion, Frank et al. (2004) hinted at the potential of this new understanding when they stated, "One direct implication of our findings is that change agents may be able to draw on social capital to facilitate the implementation of innovations" (p. 162). In other words, social capital may represent not only a factor influencing technology implementation but also a tool that may be used to ameliorate the lag in adoption of technologies in schools.

Rodgers (1995) defined change agents as "an individual who influences clients' innovation-decisions in a direction deemed desirable by a change agency" (p. 27). According to the model above, such change agents would function by accessing the expertise and social capital possessed by individual teachers, and leveraging this capital towards increasing the level of technology adoption. While they would acknowledge that many other contributing factors exist, such change agents would focus on social capital factors directly in order to set policy and achieve their goals. This simplified model assumes that the variables "social capital" and "teacher expertise" directly affect the innovation-decision process and influence the outcome in a positive manner. Such a model is presented in Figure 13.

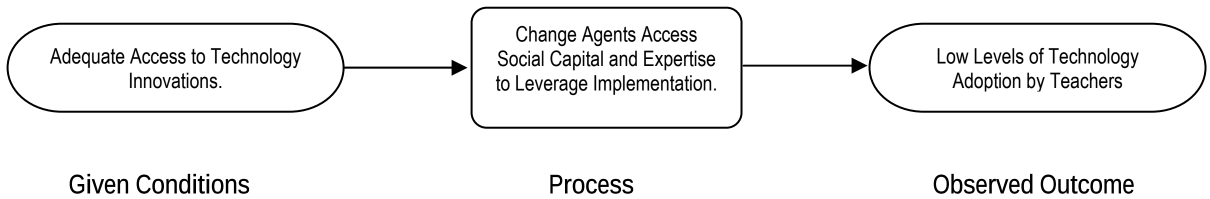


Figure 13. Simple model of technology adoption: Access to social capital and expertise.

From these models, one can see the progression of ideas beginning with diffusion of innovation in general, to applying those theories to education settings, to modeling the interaction of factors influencing technology adoption process and finally to identifying significant factors that may be used by change agents to enact improvements in technology adoption by schools.

Significant research and theory exists on the diffusion of technological innovations (Rodgers, 1995). Further, these theories have been applied in the context of education (Zhao & Cziko, 2001; Zhao & Frank 2003; Zhao et al. 2002) and empirical examination of variables influencing this process has been conducted (Frank et al., 2004). Frank et al. (2004) hinted at the need for further research when they suggested "the study could also be extended by delving deeper into each school as a case" (p. 164). Additionally, if change agents are to use this knowledge to influence the adoption of innovations in such a school, a quantitative examination of the direct relationship between social capital and technology adoption should be undertaken.

Rather than focusing on an organization, such a study would focus on the individual teacher. Since "social capital leverages expertise already in a system" (Frank et al., 2002, p. 162), it is possible to postulate that increasing social capital results in increasing the expertise of teachers. This very simple model of technology adoption, where access to social capital by itself serves as a surrogate for the entire innovation-decision process and thereby predicts the level of technology adoption by the individual teacher, is shown in Figure 14. Finally, the problem of lack of diffusion of innovation in education can be narrowed to examination of a single variable (social capital) and its effect on level of technology adoption, forming the basis for an empirical research study of the problem.

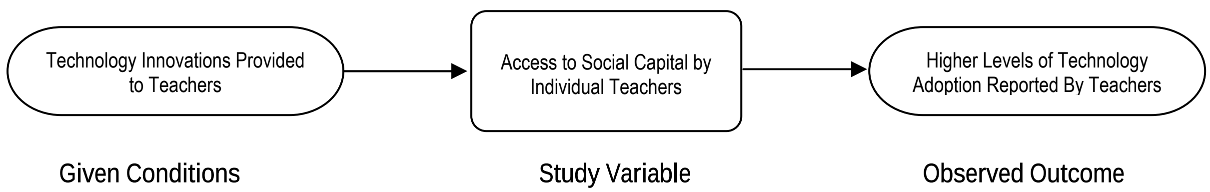


Figure 14. Simplified innovation adoption model: Focus on the individual teacher.

Should such a model prove valid, it will be of great value to change agents tasked with improving the technology adoption within a school. Because social capital is intrinsic to such organizations, employing it to achieve such a goal may be both more economically prudent and functionally feasible than efforts utilizing more traditional methods such as providing outside training, changing perceptions of the innovation, or altering prior conditions of the workplace.

Chapter 3: Methodology

In order to collect data on and analyze the relationship between teachers' adoption of innovative technologies and access to social capital, a correlational methodology using a survey instrument for data collection was selected as the most appropriate for the study. This chapter describes the details of the selected methodology.

Research Methodology

At its core, this study sought to describe the extent to which variation in access to social capital by teachers at each site corresponded to variations in level of technology adoption by those same teachers. According to Isaac and Michael (1995, p. 53), this type of question is ideally suited to exploration through correlational statistical methods because it (a) used complex variables that did not lend themselves to controlled experimental methods, (b) allowed for the examination of several variables simultaneously *in situ*, and (c) sought to quantify the degree of the relationship instead of just detecting its presence. Therefore a correlational methodology was constructed (Fraenkel & Wallen, 2003; Isaac & Michael, 1995).

The research study gathered data using survey methodologies (Buckingham & Saunders, 2004; Fraenkel & Wallen 2003; Isaac & Michael, 1995). To do so, the research was conducted in two phases. The first phase was used to customize an appropriate survey instrument for each study site, while the second involved the collection of data at three schools housed in two buildings. The following is a detailed description of the procedures used during the study. A schematic detailing the research process is included in Appendix A.

Definition of Variables

To understand the complex interactions between teachers involved in assessing both the level of adoption of innovative technologies and teachers' access to social capital, as well as examine some potentially mediating factors, it was necessary to utilize several variables to collect data. In particular, access to social capital was represented by a statistical construct of several intermediate variables. Table 3 presents the variables used in the study.

Table 3
Research Variables

Type	*Variable*
Dependent Variable	Level of Adoption
Independent Variable	Access to Social Capital
Grouping Variables (Discrete / Binomial)	Gender Assignment Grade Level
Possible Confounding Variables (Continuous)	Age Experience On-Site Experience
Comparison Variables (Used to examine reliability)	Innovator Category Social Interaction

Level of Adoption

Since the problem addressed by this research involves adoption of innovative technologies by teachers, the level of adoption measured at the study sites served as the dependent variable in the analysis. This decision is consistent with the methodology employed by Frank et al. (2004). Additional support was obtained from Hurlburt (2003), who offered, “The dependent variable is the outcome variable that is of primary interest in the study” (p. 240).

In the Frank et al. (2004) study, the researchers gathered data on adoption of innovative technologies by creating a 5-point scale coded to represent the number of days each teacher spent using computers (daily = 180, weekly = 40, monthly =9, yearly =1 and never =0). For this study, a similar methodology was adopted by asking teachers “on how many occasions did you use [technology] during the fall semester?” The decision to use a continuous scale rather than the categorical scale used by Frank et al. was based on a desire to differentiate finer variations in usage patterns as well as allow a broader selection of appropriate statistical analysis techniques (see Hurlburt, 2003; Myers and Well, 2003). This decision was based on feedback from participants in the instrument development and face validity verification phase of the study.

The following calculations were performed to assess the level of innovative technology adoption at each study site. First, the researcher coded each teacher’s level of adoption of each individual technology (x) present in the study setting from their response to appropriate questions on the survey instrument.

$$Adoption_x = days\ technology\ (x)\ used$$

Second, the overall level of adoption of innovative technology by a single teacher using all technologies in the study (n) was evaluated by using the sum of the level of adoption of each innovative technology:

$$Adoption_{Teacher} = \sum_{i=1}^{n} Adoption_n$$

Access to Social Capital

The researcher collected data and constructed this variable to examine the contribution that access to social capital makes on the level of adoption of innovative technologies by teachers. According to Myers and Well (2003), in an observational or correlational study, “The researcher does not assign subjects to treatment conditions, but instead obtains scores from subjects who just happen to be exposed to different treatment conditions” (p. 3). Therefore, the observation of teachers’ access to social capital served as the independent variable in the study.

Many factors influence access to social capital, including each teacher’s own expertise, who a teacher receives help from, the expertise of that peer, and how often that peer helps others. Each of these can be represented by a variable, with access to social capital representing a construct of those variables. To collect data for these variables, a rather complex question was used on the survey instrument. Refer to Section 4 of the sample survey in Appendix D. Data from these questions were used to define the following variables for each teacher and for each technology in the study setting:

Expertise. Based on the model used by Frank et al. 2004, level of adoption (the self-reported number of occasions a teacher used a particular innovative technology during the study period) was used directly as a measure of each teacher’s expertise.

Help received. To assess this variable, the researcher asked participants to name the colleagues who lent them assistance in learning to use each innovative technology, and to indicate on how many occasions this interaction occurred. The researcher also asked them to rate the value of this interaction for possible further use.

Help given. In Section 5 of the survey instrument, the researcher asked participants to list the persons to whom they had personally provided help and support in the context of teaching them to use each innovative technology. They were also asked to indicate on how many occasions such interaction occurred during the Fall 2007 semester.

Access to help through social capital. Adapting the statistical methodology employed by Frank et al. (2004, pp. 13-15), a measure of social capital was constructed as follows. First, a measure of the amount of help a teacher receives had to be determined. Since the level of adoption of each innovative technology for all teachers surveyed, as well as the identity of all peers providing assistance to the teacher and the number of days of such assistance was known, a teacher's access to help (AH) could be determined by simply summing the number of days the teacher received help using the following formula for calculating a teacher's access to help (H) from their (m) peers (i') relevant to a specific innovative technology:

$$AH = \sum_{\substack{i=1 \\ i \neq i'}}^{m-1} (H_{i'})$$

However, since help from experienced peers may be of more value than help from novice technology users, Frank et al. (2004) suggested the following formula may more accurately represent that access to help:

$$AH = \sum_{\substack{i=1 \\ i \neq i'}}^{m-1} (H_{i'})(Adoption_{i'})$$

This calculation included both the number of occasions the teacher sought help adjusted for the expertise (represented by level of adoption of the innovative technology being examined) of the assisting teacher who provided that assistance.

Once this value had been calculated for each teacher, the measure of access to help was improved by factoring in not only the amount of help, and the level of expertise of the person providing the assistance, but also the amount of help that each assisting person gave to other teachers. Frank et al. (2004) suggested that "our reasoning is that those who were frequently listed by others as providing help must be reasonably good at doing so" (p. 13). Therefore, a teacher's access to help in using a specific innovative technology was modeled as:

$$AH = \sum_{\substack{i=1 \\ i \neq i'}}^{m-1} (H_{i'})(Adoption_{i'})(GiveHelp_{i'})$$

Finally, access to social capital (SC) for any given teacher (i) was therefore determined simply by summing the access to help that teacher receives for each of the (n) innovative technologies examined in the study:

$$\boldsymbol{SC} = \sum_{i=1}^{n} AH_n$$

Grouping Variables

In order to more fully investigate the relationship between level of adoption of innovative technologies and access to social capital by teachers, these variables were examined across several sub-groups. The purpose of this analysis was simply to see if patterns of adoption or access to social capital were consistent between these groups. Due to the small population size, discrete, binomial variables were selected in an attempt to yield sufficient cell size in sub-groups to provide meaningful analysis. For grouping variables, dummy variables (see Myers and Well, 2003, pp. 615-621) were introduced to include these nominal or categorical data in analysis techniques requiring continuous data.

Gender. The possibility that significant differences in adoption of innovative technologies or access to social capital existed between males and females was examined by assigning participants a score of “0” for “male” or “1” for female based on their responses on the survey instrument.

Curriculum area assignment. Differences between teachers who teach academic subjects (math, science, language arts and social studies) and elective area teachers (foreign language, physical education, vocational, etc.) were also examined. The survey asked middle school teachers to report the number of hours they taught in each area (out of a 4- or 5-hour work day). Participants were assigned to the academic or elective group based on the area in which they spent the majority of their time. Elementary school teachers were asked if they taught a grade level (3^{rd} grade, for example) or an extended core class (the term used for elective classes like art or music). Grade level teachers were considered “academic” and extended core teachers were considered “elective.” Again, a score of “0” was used to indicate “academic” and “1” was used to indicate “elective / extended core” for purposes of the analysis.

Grade Level. Due to the nature of the study sites that agreed to participate (a grades 4-8 intermediate school and grades K-8 elementary/middle school), it became necessary to include elementary teachers (grades K-5) in the data collection, since both buildings had significant populations of these teachers who interacted on a regular basis with the middle school teachers. Therefore teachers were scored using "Yes" if they taught elementary school and "No" if they taught middle school. For coding purposes, "0" was used to indicate "elementary" and "1" to indicate "middle school" during the analysis.

Possible Mediating Variables

While Frank et al. (2004) determined that access to social capital is a significant contributing factor to implementation of technology innovations; they also acknowledged that many other factors contributed to the eventual adoption or rejection of new technologies. Furthermore, they acknowledged that their research remained exploratory in nature and that significant future research was needed to explore other possible contributory factors. Therefore, data were collected to explore the potential of several variables to mediate or modify the relationship between teachers' adoption of innovative technologies and those teachers' access to social capital, thereby attempting to the body of knowledge in this research area. Due to the small population and resulting small sample sizes at each study site, three common variables were selected from traditional diffusion literature for evaluation. They included the age of participants, their teaching experience, and length of time they had been assigned to the study setting.

Age. It was possible that younger teachers might have related to innovative technologies in differing ways from older teachers. Likewise, social interactions between teachers of different ages may have differed. Therefore, the age (in years) of each participant was collected.

Experience. Since adoption of innovative technologies was being studied in the context of education, it was possible that more experienced teachers may have exhibited differing attitudes and abilities related to technological innovations. Therefore, the number of years each teacher had been teaching was collected.

On-site experience. Because each study setting had a unique blend of both innovative technologies and expertise among teachers, it followed that teachers who had been assigned to the building longer may have acclimated themselves to the innovative technologies or integrated themselves into the social structure in different ways than newer teachers. Therefore, the number of years a teacher had been working at the study setting was also collected.

Comparison Variables

During the instrument development process, additional questions were added, drawn from the diffusion of innovation literature, aimed at examining adoption of innovative technologies and access to social capital by teachers at each study site, thereby allowing comparison with the study variables for the purposes of assessing the reliability of the questionnaire.

Innovator categories. The study drew from the work of Rodgers (1995, pp. 262-264) and his definitions of *innovator categories* to have teachers self-assess the degree to which they adopt innovative technologies. Rodgers grouped members of an organization as innovators, early adopters, early majority, late majority, and laggards based on how quickly they were to fully adopt the innovation.

For each technology in the study, participants were asked to indicate which group they belonged to by selecting a response that best described their use of each innovative technology present at the study site. Table 5 shows Rodgers' categories and the matching prompt from the survey instrument.

Table 4

Innovator Categories

Innovator Categories Rodgers (1995)	Survey Questionnaire Prompt
Innovator	"I was using this technology before anyone else was aware of it"
Early Adoptor	"I was among the first to use this technology when it became available"
Early Majority	"Less than half of the staff was using this technology when I started using it"
Late Majority	"More than half of the staff was using this technology when I started using it"
Laggard	"I have not yet begun to use this technology"

Social interaction. Similar to the *access to social capital* variable, this variable was constructed from participants' responses to multiple variables. Drawing from Frank et al.'s (2004) methodology, participants were asked to self-assess both the help they received from other teachers as well as the help they provided in return. To gather this data, a 5-point Likert scale (1 = "Strongly Agree," 2 = "Agree," 3 = "Neither Agree nor Disagree," 4 = "Disagree," 5 = "Strongly Disagree") was used to elicit responses to two questions. The first question was designed to assess help received: "The knowledge, skills, training and support I receive from my colleagues helped me incorporate innovative technologies into my daily teaching practice." The second was designed to assess the help they gave to their colleagues: "The help I gave to my colleagues allowed them to successfully incorporate innovative technologies into their daily teaching practice."

The measure of social interaction was calculated by simply multiplying the help received by the help given, consistent with the method used to calculate social capital.

Study Population, Participants, and Sampling Plan

Potential research participants were available in a single medium-to-large Midwestern, urban school district. Teachers from this pool were selected to serve as participants in the study. The following descriptions represent the specifics used in participant selection and recruitment.

Sampling Plan

As mentioned previously, data collection took place during a scheduled, bi-weekly staff meeting. The plan was to have all such teachers in attendance participate in the survey questionnaire—comprising a census of teachers at each site. While 100% participation would have been ideal, it was anticipated that at least 75% of teachers would choose to participate, yielding a sample of 30 to 45 individuals per study site. This plan represented the reality that some teachers either would inevitably miss the data collection meeting or choose not to participate.

This sampling plan represented a convenience sample. However, the limited size of the teacher population at each site, compared to the sample size necessitated by the correlational methodology selected, prohibited the use of true random sampling for this study.

Study Populations

The unit of analysis for the study was three individual schools housed in two school buildings located in a single school district. Due to differences in setting, as well as innovative technologies present at each site, each school represented a single, independent unit of observation. The selected school district contained approximately three high schools, seven middle and intermediate schools, and fifteen elementary schools. Individual elementary schools were initially ruled out as potential study sites due to the low population of teachers present in each building (generally less than twenty). The large high schools were also ruled out due to issues of accessibility (all three were involved in complex accreditation projects, and initial contact with principals suggested that they would not be able to fully participate).

Both Fraenkel and Wallen (2003) as well as Isaac and Michael (1995) suggested a minimum of thirty participants in a sample to ensure valid results using correlational analysis. Combined with other factors, this minimum number of participants led to the identification of middle or intermediate schools within the district as ideal sites for the study. After contacting the principals at these schools, three buildings volunteered to participate. Due to scheduling conflicts, one of the three eventually dropped out of the study, leaving two buildings available for the study. Data collection occurred at each site during regularly scheduled, bi-weekly staff meetings. This allowed access to nearly all of the staff members assigned to each site.

During the instrument development phase, it was noted that both of the schools being studied shared a common building with an elementary school. The first study site was the district’s only intermediate school and therefore included six elementary teachers (grades 4-5) among its staff. These teachers interacted daily with the middle school staff and attended all meetings and professional development sessions. Therefore, these teachers were included in the data collection as part of the intermediate school staff.

The second school consisted of the middle school staff assigned to one of two “K-8 elementary” schools in the district. This building housed both a traditional grades K-5 elementary and grades 6-8 middle school within the same building. Each staff functioned as an independent unit, with differing work schedules, meeting days, and so on. Therefore, the middle school teachers were sampled during a Monday meeting and the elementary teachers several weeks later on a Wednesday. The original intent was to use the elementary school as a third independent study site.

However, since the approximately twenty elementary teachers constituted a very small sample but did share common resources (including available technologies) and frequently interacted with the middle school staff in common areas, both schools were combined into a single combined sample. This is consistent with the district’s conventions as both schools share a common administration and secretarial and support staff, as well as being housed in a single building.

Since the technologies present at each school were likely to be unique, and each setting was likewise individual, it was important to note that these schools could not be combined into a single population but rather represented individual, independent populations for purposes of the study. While results of the study in each building are therefore not generalizable outside of the that building’s population, the inclusion of two populations did allow some comparison of results and a degree of practical transferability of results to similar populations within the district.

Study Participants

Participants for the study were drawn from the teachers assigned to the schools serving as study sites. Thirty-nine participants from 46 teachers available at the first site completed surveys: 33 middle school and 6 elementary school teachers. Thirty-three middle school teachers were sampled from the 50 teachers available at the second site and 21 elementary school teachers from the 23 available at the third site. The last two samples were later aggregated into a single 53-teacher sample from 72 available at the combined site. The discrepancy in totals at the merged site was due to the inclusion of a single teacher assigned to both sites, who turned in an identical questionnaire at both sites. In total, 92 of a potential 112 teachers (82%) chose to participate in the study.

The first site was a grade 4-8 intermediate school. This meant that both elementary and middle school teachers were present at the site. Several factors contributed to determining how to group these participants. First, both staffs were housed in the same building and shared the facility, common resources, administration and support staff. Second, since only 4th and 5th grade are taught at the school, there were relatively few elementary teachers. However, those elementary teachers shared common work schedules and lunch and planning time, as well as having attended and participated in all staff meetings and other building functions. Therefore it was determined that they composed a single social network within the building and were combined and treated as a single population for purposes of the study.

Likewise, the second site—a K-8 elementary/middle school—also had both elementary and middle school teachers assigned to the building. They similarly shared common administration, facilities, and technologies. However, because the building housed kindergarten through 5th grade as well as middle school, there were significantly more elementary school teachers assigned to the building (23 as compared to 6 at the first site). Furthermore, the elementary and middle school staff had different work schedules, different meeting days, and reported to different assistant principals. Therefore, they were originally treated as independent samples and data were collected on two different occasions.

However, some contradictory evidence emerged that seemed to suggest that the two staffs actually composed a single social network. These include the fact that they were both housed in a relatively new (3-year-old) building and took a lot of pride in their school. They also shared common facilities (gym, media center, cafeteria, etc.) and access to the same innovative technologies. In fact, the same survey questions were used at both sites, with the sole exception of a wording change on question #6 to reflect the different naming conventions used at each level for academic versus elective teachers. Additionally, examination of the questionnaires revealed that a few middle school teachers reported receiving assistance from elementary teachers in learning to use technologies, and vice versa.

Since the case could be made either way, data from the second site were reported as "Site 2" to indicate the middle school staff and "Site 3" to indicate the elementary staff. To include the possibility that they are actually a single social network, data were also reported for "Site 2 + Site 3 combined" to indicate the unified K-8 staff.

Human Subjects

Since the research collected data or information from and about human subjects, the researcher took the required precautions to insure the safety, confidentiality and anonymity of the subjects as required by the *EMU Dissertation Manual (*2006, pp. 6, 9, 13). Prior to beginning the study, the *Protection and Use of Human Subjects in Research Certification* (Appendix E) program offered by the Eastern Michigan University

Graduate School was completed and submitted. The *Eastern Michigan University Request for Human Subjects Approval* (2006) form (Appendix F) was submitted to the University Human Subjects Review Committee (UHSRC). Approval to conduct the study was granted by the UHSRC on January 18, 2008 (Appendix G). As the instrument development and pilot survey progressed, the modified survey instruments were re-submitted to the UHSRC for approval, which was granted on February 18, 2008 (Appendix H).

Because of the nature of research on social capital, it was necessary to collect specific identifying information from study participants, including name, gender, teaching assignment information, years of teaching experience, and age. Due to this requirement, significant efforts had to be undertaken to protect the participants' anonymity and confidentially both during data collection and in the final publication. Specifics of these efforts are included in the *Request for Human Subjects Approval* (2006) form (Appendix F).

Instrument Development

Developing a valid instrument is a complex, time-consuming, and demanding undertaking (Buckingham & Saunders, 2004; Fraenkel & Wallen, 2005; Isaac & Michael, 1995). Due to the complexities of the research questions, the differing innovative technologies at each study site, and the unique characteristics of the participants, population, and study setting, no suitable instrument could be located appropriate to conduct an examination of the research variables. Frank et al. (2004) provided a survey with their study, which served as the basis for developing a suitable survey as well as methodology for evaluating variables for technology adoption and access to social capital. Therefore, the study utilized the following procedure to customize the necessary instrumentation for each study site.

First, following a review of relevant literature, specific study sites were identified and selected based on characteristics appropriate for the study methodology. These included having a staff large enough to provide data appropriate for correlational analysis techniques (approximately 30 needed), the presence of various technologies that might be considered innovative, a willingness to participate, and availability of suitable meeting time with which to collect data from staff members.

Permission was sought from the district superintendent as well. Since it was necessary to know if the district was available for research prior to submitting the dissertation proposal, this request was made prior to formal approval of the proposal. Such permission was granted on December 13, 2007, via an email (Appendix J).

Identification of innovative technologies present in study setting.

Since the research was founded on the exploration of adoption of innovative technologies by teachers, the first consideration had to be precisely defining exactly which innovative technologies were to be explored in the study. Using Rodgers' (1995) definition of an innovation as "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (p. 11), the process began by examining available historical documentation for insight into which ideas, practices, or objects might meet this definition in the study site. These documents include the district's strategic plan for technology, minutes of the district Technology Advisory Committee (TAC), and the building's School Improvement Plan (SIP), all of which were publicly available via the district website.

In order to determine which innovative technologies should be included in the study, the researcher met with and interviewed several key policy makers at each study site. An outline/script of these interview sessions is included in Appendix B. These interviews included the principal and assistant principal(s), several teachers (both middle and elementary level), building media specialists, and assigned computer technicians. The interviews focused on identifying a few (2-3) key innovative technologies present and widely accessible by teachers at the study setting.

During the interviews, approximately a dozen potential innovative technologies were identified at each site. Discussions continued until all participants could agree on a list of 3-4 innovative technologies to focus on for each site. Sometimes it was decided that several innovative technologies could be encompassed under a single innovative technology. For instance, in one school, several online resources were being used by teachers. However, it was decided that use of these sites was dependent on teachers' access to computers for their students. Since the school had both common computer labs and mobile laptop computer labs that teachers could use, it was decided to assess the use of the labs, rather than the use of each online resource.

However, participants also felt that specific use of many technologies was important. While data resulting from these questions was not within the scope of the researcher's analysis of adoption of innovations and access to social capital, it was nonetheless collected to provide a more complete view of how these innovative technologies were used at each site for potential future research.

Customization of Draft Instrument

Once the key innovations had been identified for each site, the researcher and key policy makers at each site formulated questions about each innovation using Frank et al.'s (2004, p. 11) survey and the interviews as a guideline.

First, the level of each teacher's use of each technology was assessed by asking "On how many *occasions* did you use [*technology X*] for during the 2007 Fall semester (September 4, 2007 through January 23, 2008)?" The use of the continuous variable *occasions* rather than Frank et al.'s (2004) ordinal 5-point scale (daily=180; weekly=40; monthly=9; yearly=1; never=0) was intended to provide finer differentiation between levels of adoption of innovative technologies during the 90-day analysis period. The question was repeated for each technology in the study. In addition, follow-up questions were asked for some technologies to collect data on the various ways teachers might use that technology. Refer to sample instrument in Appendix D.

In order to determine access to training, help, and support through social interactions, data on both how often each teacher received help, as well as how often he/she provided such support was collected. Additionally, in order to examine the magnitude of this support, it was necessary to determine the identity of the person providing/receiving this assistance.

To achieve this, two questions were asked: First, to assess the amount of help a teacher received, the survey asked: "Reflect on the teachers who helped you learn to use <u>[Technology X]</u> during <u>Fall Semester 2007</u> (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you received such help from each person. Last, for each person, please check the box that best describes how helpful their help, training and support was as you learned to use [Technology X] during Fall Semester 2007 (September 4, 2007 to January 25, 2008)."

To assess the amount of assistance that the teacher provided to others, the survey asked: "Reflect on the teachers who *you* helped learn to use [Technology X] during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you provided such help to that person."

As with the level of adoption of innovative technologies, these questions used the continuous variable *occasions* rather than Frank et al.'s (2002) categories.

With data from these questions, it was possible to calculate and assign each teacher a value representing both their level of adoption of the innovative technologies present in the building, as well as their access to social capital.

Once questions had been developed for evaluating the relationship between these variables, it was necessary to collect information to examine that relationship among several sub-groups based on demographic variables. Therefore, questions were included that asked gender (male/female), age (years), experience (years teaching), assignment (years teaching at the study site), course taught (core academic/elective). Again, refer to Appendix D for specific questions used.

Instrument Validity

Once these customized instruments had been modified, a sample instrument was produced and shared with a panel of eight experts familiar with the study site, diffusion of innovation theory, and/or survey design and statistical analysis (Appendix C). These experts were drawn from the school district and local universities, as well as other PhD students in the researcher's cohort.

The purpose of this examination was to establish the *face validity* (Buckingham & Saunders, 2004, p. 65) and *content-related validity* of the instrument (Fraenkel & Wallen, 2003, p. 159). Feedback was received from six of these experts. Based on their suggestions, several minor corrections were made, as well as the inclusion of a section of the survey instrument in which participants self-assess their innovator category (Rodgers, 1995, p. 262), as well as their access to help from colleagues and help provided to their peers. This data were collected in to provide a cross reference to data collected on adoption of innovation and access to social capital in an effort to provide a preliminary measure of instrument reliability.

Pilot Study and Instrument Revision

Once the instrument had been developed, a small pilot study was conducted at the district's math/science/technology academy on January 18, 2008. This site was chosen based on its similar size and characteristics to the study sites, as well as its proximity and accessibility to the researcher.

The purpose of this pilot study was to have participants fill out the survey questionnaire and give the researcher feedback on issues of readability, clarity, and interpretation. Additionally, the data collected allowed the researcher to set up his data-recording protocols and run some tests of analysis techniques to insure that data collected was appropriate for the analysis techniques proposed. Feedback from participants was used to make revisions to the instrument. These included additions to the instructions, rewording of several questions, correction of various spelling and grammatical errors, and the inclusion of reminders on several questions.

Instrument Finalization and Approval

After modification to the surveys based on input from both the pilot group and the panel of experts, final copies of each instrument were produced and forwarded to the UHSRC for final approval (Appendix H).

Data Collection Procedure

Data were collected from participants at each site in a single session, utilizing an existing all-staff meeting. These meetings were held on the first and third Monday of every month. However, the first meeting also coincided with department meetings, and was therefore unavailable as a data collection date. Since the focus of the survey and period of observation was the Fall 2007 semester, an attempt was made to collect data on the first several of these meetings of the second semester. This requirement, along with need for the researcher to be present at data collection, imposed a restriction on the number of research sites that could be evaluated during the study.

Data were collected using the following protocol: Building administrators and other personnel not participating in the study were asked to leave the room, thereby insuring the anonymity and confidentiality of respondents. The researcher began by providing participants with a brief description of research problem, questions, and procedures. A cover letter (Appendix K) and two copies of the informed consent agreement (Appendix I) were distributed to all participants.

After discussing the survey, passing out and collecting one copy of the informed consent letters, and addressing any questions or concerns brought forth by teachers, the survey instrument was distributed to each participant. The researcher personally read the instructions out loud to participants and remained available to answer questions as participants filled out the questionnaire. Completed surveys were hand collected and sealed in a large envelope until coding and entry into statistical software. Upon completion and verification of data entry, original paper surveys were destroyed by shredding. Teachers who elected not to participate remained in the room during data collection but were not required to fill out a survey (a total of only one teacher fit this category).

There were a total of 31 teachers who did not attend these meetings for a variety of reasons (12 at the first site, 17 at the second site, and two at the third site). These teachers received a follow-up email (Appendix L) describing the research and asking them to participate. The cover letter, informed consent agreements, and survey instrument were sent to them via the inter-school mail system, along with a copy of the email request.

Based on the low response to this email, a final follow-up email was sent on March 21, 2008 (Appendix M), in an effort to obtain a few more responses.

One missing survey from the first site, three from the second, and two from the third were received and added to the appropriate data set. Since all participants were available at the third site (though one elected not to participate and one was out on medical leave and unavailable) these emails were not sent to participants at that building.

Data Analysis

Once information had been collected, it was coded and entered into a Statistical Package for the Social Sciences (SPSS) database. This software allowed a variety of statistical methods to be employed to aid in finding answers to the research questions. The specific statistical methods used to describe the data and answer each research question are presented below:

1. What technologies that may be labeled as innovative existed in the study settings? Data collected in the interview and document collection process were presented using a table showing the name of each technology. A narrative was included to describe the results of the data collected and to support selection of these technologies.
2. What was the current level of adoption of these innovative technologies by teachers in the study settings? Simple descriptive statistics including range, mean, median, mode, standard deviation, histograms, and tables were used to describe adoption of innovative technologies. Skewness, kurtosis, and the Shapiro-Wilk *W* test of normality were used to test for normal distribution of adoption data. Additionally, Cronbach's *alpha* was used to evaluate the reliability of the instrument in determining the level of adoption of innovative technologies using the innovator category self-assessment data as a comparison.
3. What was the current level of access to social capital by teachers in the study settings? While the construct variable used to examine this question is fairly complex, the same descriptive statistics statistical methods used to describe level of adoption were employed to describe access to social capital. Skewness, kurtosis and the Shapiro-Wilk *W* test of normality were used to test for normal distribution of access to social capital data. Additionally, Cronbach's *alpha* was

used to evaluate the reliability of the instrument in determining the level of access to social capital using the social interaction self-assessment data as a comparison.

4. Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of adoption of innovative technologies? In order to evaluate whether differences exist among groups, the Mann-Whittney *U* test was used to test a non-directional hypothesis: H_0: No differences in adoption of innovative technologies exist between male and female teachers (for example). This test was deemed most appropriate due to the small sample size and skewed distribution of data.
5. Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of access to social capital? In order to evaluate whether differences exist among groups, the Mann-Whittney *U* test was used to test a non-directional hypothesis: H_0: No differences in access to social capital exist between academic and elective teachers (for example). This test was deemed most appropriate due to the small sample size and skewed distribution of data.
6. Did a relationship exist between teachers' access to social capital and level of adoption of innovative technologies in the study setting? Due to the nature of the data, the non-parametric Spearman's *rho* was used to calculate a correlation coefficient (r_s) to test the following hypothesis at an $\alpha = .05$ level of significance: H_0: No relationship exists between level of adoption and access to social capital.

7. Did a relationship exist between several potentially confounding variables (age, experience, on-site experience) and level of innovative technology adoption by teachers in the study setting? Spearman's *rho* was used to calculate a correlation coefficient (r_s) to test the following hypothesis at an $\alpha = .05$ level of significance: H_0: No relationship exists between implementation and (potential confounding variable).
8. What was the relationship between level of adoption of innovative technologies and access to social capital by teachers controlling for any confounding variables identified in questions 5-7 above? The potentially confounding variables for this study included gender (male or female), assignment (academic or elective), grade level (elementary or secondary), age (in years), experience (years teaching), and on-site experience (years teaching at the study site). For any confounding variables found to be significant at an $\alpha = .05$ level of significance, partial correlation could be used to re-evaluate the relationship between level of adoption and access to social capital (the zero-order correlation) while controlling for significant co-variables (the 1st or 2nd order correlation). However, no such significant confounding variables were detected during the study, and therefore this analysis was not performed.

Results of all statistical analysis were reported using standard notations, graphs, and tables as indicated in the American Psychological Association (APA) *Publications Manual (5th ed.)* (2001).

Summary

Three schools housed in two buildings were identified as study sites for this research study. Teachers at each site composed three independent populations (units of analysis). A census of teachers at each site was attempted. Because several teachers chose not to participate, the resulting participants represented a convenience sample of each population.

After innovative technologies were identified by a panel of experts at each site, a custom survey questionnaire was developed and validated for each study setting. This instrument was used to collect data used to answer the research questions.

A variety of parametric and non-parametric statistical techniques were used to describe and analyze the data. Correlational techniques were used to examine the relationship between teacher's level of adoption of innovative technologies and access to social capital.

Chapter 4: Findings, Analysis, and Discussion

This chapter describes the data and presents the findings and analyses derived from those data. Demographic data used to describe the study sites were obtained through review of public documentation. Data from the instrument development process used to answer Research Question 1 were obtained from informal interviews and conversations with key policy makers at each site. Data used to answer the remainder of the research questions were obtained from survey questionnaires filled out by participants during a single staff meeting at each study site. Included in each section is some brief discussion of the justification of the analysis being performed, as well as a summary of the findings.

Research Question 1

What technologies that may be labeled as innovative existed in each study setting?

There were two aspects of this questions that needed to be answered. First, specific sites suitable for data collection had to be identified. Based on the unique characteristics of each of those sites, data were collected to identify technologies that were present at each site and considered innovative.

Site Selection

A single medium-to-large, midwestern, urban school district served as the overall setting for the survey. From the seven middle/intermediate schools and 19 elementary schools in the district, three schools volunteered and were selected to participate in the study. Site 1 was a grade 4-8 intermediate school, while Site 2 and Site 3 were a grades K-5 elementary and grades 6-8 middle school, respectively. Both were housed in a single grade K-8 building sharing common administration and support personnel. Table 5 presents a brief demographic summary of each site.

Table 5
Study Site Demographic Data

	Type of School	Grade Level	No. Students	No. Staff	Staff Assignment
Site 1	Intermediate	4-8	505	46	40 middle 6 elementary
Site 2	Middle	6-8	615	50	50 middle
Site 3	Elementary	K-5	429	23	23 elementary
Site 2 + Site 3[a]	Merged	K-8	1044	72[b]	49½ middle 22½ elementary

[a]Sites 2 and 3 are presented both individually and together as they are both housed in the same facility.
[b]Discrepancy in total is due to a single participant participating in both surveys with identical questionnaires, due to job assignment in both settings.

Innovative Technology Identification Meetings

As detailed in the methodology section of this dissertation, the survey instrument was based on that used by Frank et al. (2004), modified to address the adoption of several innovative technologies at each site, rather than a single technology. In order to tailor the survey questionnaire to each individual study setting, the researcher met with key technology policy makers at each school. The purpose of these meetings was to identify the innovative technologies present in each building. Those involved in these meetings included the researcher, representatives of building administration, district technology technicians, and other support personnel as well as classroom teachers assigned to the site. These meetings generally lasted approximately 90 minutes and resulted in a group consensus identifying the 3-4 innovative technologies to be examined at each site. The persons in attendance as well as innovative technologies identified are detailed in Table 6. Attendees' names were withheld to protect their anonymity and confidentiality, as specified in the informed consent agreement (Appendix I). For details of these meetings, see Appendix B.

Table 6

Instrument Development Meeting Summary

	Meeting Date	Participants	Innovative Technologies Identified / Selected[b]
Site 1	January 25, 2008	▪ Researcher ▪ Principal ▪ Assistant Principal ▪ Building Technician ▪ Counselor / Technology Advisor ▪ Media Specialist ▪ Science Teacher / Technology Committee Chair	▪ Document Camera (ELMO) ▪ Computer Labs (dedicated and mobile) ▪ Digital Cameras and Video Cameras ▪ Data Projectors
Site 2 + Site 3 Combined[a]	January 28, 2008	▪ Researcher ▪ Principal ▪ Assistant Principals (2) ▪ Computer Lab Manager ▪ Media Specialist ▪ Elementary Bilingual Specialist (Teacher) ▪ Middle School Language Arts Teacher	▪ Promethean Boards ▪ Mobile Computer Labs ▪ Dukane DVD/VHS System

[a]Instrument development for sites 2 and 3 was conducted at the building level and included administrators and support staff common to both buildings as well as teacher representatives from both elementary and middle school staffs.
[b]Technologies were referred to by these names in the instrument, but are coded in order (top to bottom) for each site as "Technology 1, Technology2, Technology 3, Technology 4" in the data analysis to allow comparison between sites.

Summary of Results, Research Question 1

Based on the data available, the researcher identified four innovative technologies at Site 1 (Document Camera [ELMO], Computer Labs, Digital and Video Cameras, LCD Projectors) and three identical innovative technologies at Sites 2 and 3 (Promethean Boards, Mobile Computer Labs, Dukane DVD/VHS System).

It is important to note that many technologies were identified as innovative at each site. This stands in stark contrast to much of the existing diffusion of innovation literature (see Cuban et al., 2001; Frank et al., 2004; Lancaster & Lancaster, 2002;

Loveless, 1996; Smerdon et al., 2000; United States Congress OTA, 1995; Wells & Lewis, 2006) that tend to focus on a single innovation.

Interesting comparisons among the types of technologies identified as innovative also emerged from these findings: All study sites identified computer labs as innovative. Likewise, all sited identified technologies that served similar purposes as innovative (the Document Camera [ELMO], LCD Projectors and Promethean Board are all used to display instructional materials via a projection system). However, each site also identified unique technologies as innovative (the DVD/VHS Dukane system and Digital/ Video Cameras).

These findings supported the researcher's decision to treat each study site as an independent sample, since variations among innovative technologies served to define each study site as a unique population and prohibited the combination of findings into a single over-arching sample.

Research Question 2

What was the current level of adoption of these innovative technologies by teachers in the study setting?

Based on the methodology used by Frank et al. (2004), information used to evaluate this question was obtained by asking teachers to report how many occasions during the Fall 2007 semester they used each innovative technology identified in their building. The level of adoption was simply the sum of these occasions. Table 7 summarizes the total level of adoption for each technology at each setting.

Table 7

Mean Level of Adoption of Innovative Technologies

		Technology 1		Technology 2		Technology 3		Technology 4[a]		Total Level of Adoption	
	N	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Site 1	39	77.69	134.14	69.82	112.75	9.92	23.381	19.29	19.959	154.95	238.07
Site 2	33	9.94	27.024	10.24	18.16	4.70	9.49	--	--	24.88	36.96
Site 3	21	5.14	11.13	3.29	4.52	1.95	8.72	--	--	10.38	20.66
Site 2+3 Merged	53[b]	7.66	22.21	7.30	14.82	2.94	7.78	--	--	17.91	30.96

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Preliminary examination of these results revealed that the teachers at Site 1 exhibited a much higher mean level of adoption of innovative technologies ($\bar{x}$ =154.95 occasions per semester) followed by Site 2 ($\bar{x}$ =24.88 occasions per semester), while Site 3 showed the lowest level ($\bar{x}$ =10.38 occasions per semester). The merged data from Sites 2 and 3 combined showed a level of adoption ($\bar{x}$ =17.91 occasions per semester), roughly half way between Sites 2 and 3, as expected. Similarly, the individual innovative technologies at each school also showed differing levels of adoption ranging from the highest reported level of adoption (the document camera [ELMO] at Site 1, $\bar{x}$ =77.69 occasions per semester) to the lowest (mobile computer labs at Site 3, $\bar{x}$ =3.29 occasions per semester).

Before these findings could be used in further statistical analysis, a more rigorous examination of the data was conducted to establish the suitability of the data for the chosen analytic techniques. First, the distribution of the adoption data for each individual innovative technology at each site was examined (Table 8).

Table 8

Distribution of Adoption Data by Innovative Technology

	N		Range		Mean		Median	Mode
	Valid	Missing	Min	Max	$\bar{x}$	s		
Site 1								
Document Camera (ELMO)	39	0	0	500	77.69	134.14	20	0
Computer Labs	38	1	0	500	69.82	112.754	42.50	0
Digital and Video Cameras	39	0	0	100	9.92	23.38	1	0
LCD Projectors[a]	38	1	0	90	19.29	19.95	13.50	0
Total Level of Adoption	39	0	0	1038	154.95	238.07	99	0
Site 2								
Promethean Boards	33	0	0	100	9.94	27.02	0	0
Dukane DVD/VHS	33	0	0	90	10.24	18.16	5	0
Mobile Computer Labs	33	0	0	40	4.70	9.49	0	0
Total Level of Adoption	33	0	0	150	24.88	36.96	8	0[b]
Site 3								
Promethean Boards	21	0	0	40	5.14	11.13	0	0
Dukane DVD/VHS	21	0	0	20	3.29	4.52	2	1
Mobile Computer Labs	21	0	0	40	1.95	8.72	0	0
Total Level of Adoption	21	0	0	90	10.38	20.66	4	0[b]
Site 2 + Site 3 (Merged)								
Promethean Boards	53[c]	0	0	100	7.66	22.21	0	0
Dukane DVD/VHS	53[c]	0	0	90	7.30	14.82	3	0
Mobile Computer Labs	53[c]	0	0	40	2.94	7.78	0	0
Total Level of Adoption	53[c]	0	0	150	17.94	30.96	5	0

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Multiple modes exist, lowest value reported.
[c]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Aside from the obvious differences between levels of adoption of the various innovative technologies, marked divergence among mean, median, and mode for these technologies was identified. Also noted were the relatively large standard deviation values compared to the means. According to Myers and Well (2003, p. 124), this could be indicative of a non-normal distribution. Additionally, the existence of two innovative technologies that displayed multiple modes suggested that the data did not meet the unimodal assumption of normality (Hurlburt, 2003, p. 41). In order to further examine these possibilities, the distribution of adoption data was displayed graphically using histograms (Appendix N, Figure N-1). A representative example of these histograms is presented in Figure 15.

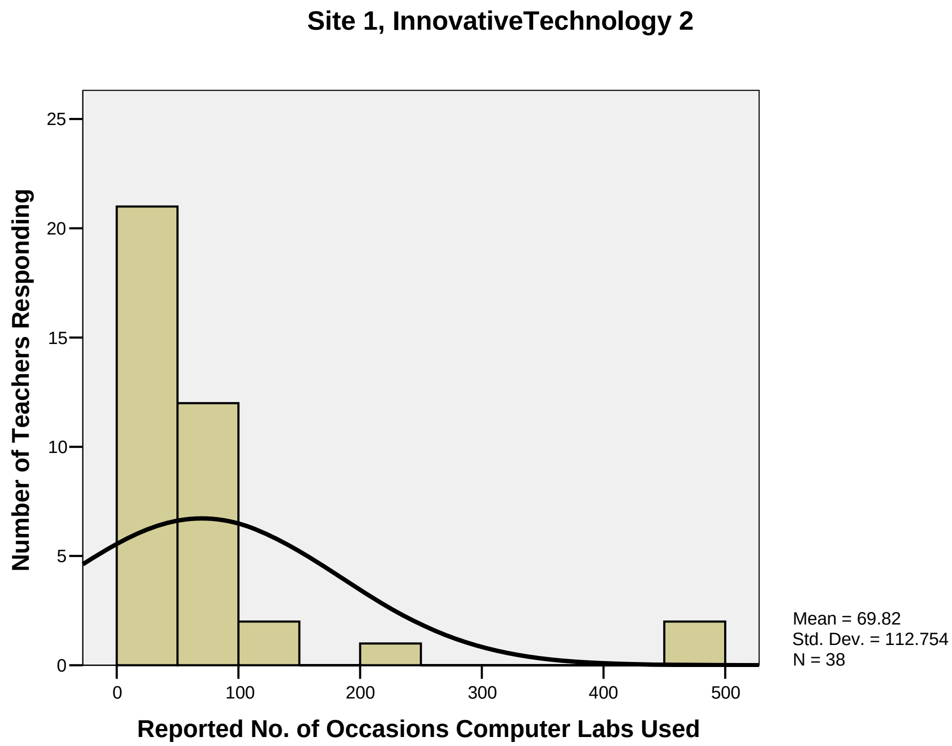


Figure 15. Representative example of a histogram for adoption data.

Visual examination of these histograms further suggested that, in addition to the divergence in measures of central tendency, these data displayed a strongly negative skew, providing further evidence against supporting the assumption of normality. To further test the distribution of these values, both skew and kurtosis values were computed for each innovative technology at all study sites. Table 9 presents the results of these analyses.

Table 9

Skew and Kurtosis Values for Level of Adoption Data.

	N		Skewness		Kurtosis	
	Valid	Missing	Statistic	Std. Error	Statistic	Std. Error
Site 1						
Document Camera (ELMO)	39	0	2.402	.378	4.919	.741
Computer Labs	38	1	3.113	.383	10.336	.750
Digital and Video Cameras	39	0	3.001	.378	8.550	.741
LCD Projectors[a]	38	1	1.603	.383	3.071	.751
Total Level of Adoption	39	0	2.934	.378	8.830	.741
Site 2						
Promethean Boards	33	0	2.779	.409	6.526	.798
Dukane DVD/VHS	33	0	3.451	.409	12.916	.798
Mobile Computer Labs	33	0	2.581	.409	6.428	.798
Total Level of Adoption	33	0	1.969	.409	3.348	.798
Site 3						
Promethean Boards	21	0	2.366	.501	4.926	.972
Dukane DVD/VHS	21	0	2.864	.501	9.573	.972
Mobile Computer Labs	21	0	4.578	.501	20.970	.972
Total Level of Adoption	21	0	3.333	.501	11.850	.972
Site 2 + Site 3 (Merged)						
Promethean Boards	53[b]	0	3.352	.327	10.651	.639
Dukane DVD/VHS	53[b]	0	4.368	.327	21.264	.639
Mobile Computer Labs	53[b]	0	3.438	.327	12.173	.639
Total Level of Adoption	53[b]	0	2.606	.327	6.844	.639

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Two observations lent credence to dismissing the assumption of normality for these data. According to Myers and Well (2003, p. 30), the relatively large positive skew values indicated that the data were skewed negatively. Also, the ratio of skewness to its standard error, being much greater than 2, suggested that the data were asymmetrical and therefore not normally distributed. Likewise, since the values for kurtosis were positive, greater than 3, and much larger than their standard errors, Myers and Well (2003, p. 30) suggested that the distribution is high peaked and heavy tailed, and therefore also departed from the normal distribution. They also suggested that this may be due to small samples and/or extreme (outlier) values. Elimination of these values was deemed impossible, as it would have reduced already small sample sizes, especially in analysis of differences between groups.

Since preliminary analysis suggested that the data were not normally distributed, the Shapiro-Wilk *W* test was used to empirically test for normality in the adoption of innovative technologies data. Table 10 reflects the results of this analysis.

Table 10
Shapiro-Wilk W test for Normality for Level of Adoption Data.

	W	*d.f.*	*Sig.*
Site 1			
Document Camera (ELMO)	.555	39	.000**
Computer Labs	.574	39	.000**
Digital and Video Cameras	.399	39	.000**
LCD Projectors[a]	.830	39	.000**
Total Level of Adoption	.607	39	.000**
Site 2			
Promethean Boards	.417	33	.000**
Dukane DVD/VHS	.548	33	.000**
Mobile Computer Labs	.564	33	.000**
Total Level of Adoption	.676	33	.000**
Site 3			
Promethean Boards	.545	21	.000**
Dukane DVD/VHS	.662	21	.000**
Mobile Computer Labs	.237	21	.000**
Total Level of Adoption	.515	21	.000**
Site 2 + Site 3 (Merged)			
Promethean Boards	.395	53[b]	.000**
Dukane DVD/VHS	.470	53[b]	.000**
Mobile Computer Labs	.438	53[b]	.000**
Total Level of Adoption	.594	53[b]	.000**

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
**Significant at the α=.01 level

The results of this analysis allowed the researcher to reject the null hypothesis (H_0= adoption data is normally distributed) and conclude that the data were best suited to statistical analytical techniques not dependent on the assumption of normality.

Other Measures of Adoption of Innovative Technologies

A second measure of adoption was the self-reported innovator category reported by participants for each innovation (Table 11).

Table 11

Summary of Innovator Category Data

	N		Range		Mean		Median	Mode
	Valid	Missing	Min	Max	$\bar{x}$	s		
Site 1								
Document Camera (ELMO)	36	3	1	5	3.31	1.064	3.50	4.00
Computer Labs	37	2	1	5	3.30	.996	3.00	4.00
Digital and Video Cameras	34	5	1	5	3.50	1.228	3.50	4.00
LCD Projectors[a]	35	4	2	5	4.00	1.095	4.00	4.00
Mean Innovator Category	38	1	1.5	5	3.50	.924	3.50	4.00
Site 2								
Promethean Boards	29	4	1	5	4.31	1.442	5.00	5.00
Dukane DVD/VHS	30	3	1	5	3.20	1.297	3.50	4.00
Mobile Computer Labs	29	4	1	5	3.31	1.285	3.00	3.00
Mean Innovator Category	30	3	1	5	3.61	1.065	3.83	4.33
Site 3								
Promethean Boards	20	1	2	5	4.10	1.165	5.00	5.00
Dukane DVD/VHS	18	3	1	5	3.28	1.179	4.00	4.00
Mobile Computer Labs	20	1	1	5	4.05	1.317	5.00	5.00
Mean Innovator Category	20	1	1.67	5	3.84	.884	4.00	4.67
Site 2 + Site 3 (Merged)[c]								
Promethean Boards	48	5	1	5	4.27	1.300	5.00	5.00
Dukane DVD/VHS	47	6	1	5	3.28	1.210	4.00	4.00
Mobile Computer Labs	48	5	1	5	3.65	1.329	5.00	5.00
Mean Innovator Category	49	4	1	5	3.75	.959	5.00	4.00[b]

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Multiple modes exist, lowest value reported.
[c]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

The primary reason these data were collected was to establish the reliability of the survey instrument to accurately assess the level of technology adoption by teachers at the study site. To do so, the researcher calculated Cronbach's *alpha* (Fraenkel & Wallen, 2003, p. 168) for each site, using the individual innovative technology adoption data, individual technology adopter category responses, total innovative technology adoption data and mean technology adopter level. Unfortunately, the self-assessment variables were opposite in direction, with higher levels of adoption of innovative technologies equating to lower scores on the innovator category self-assessment. In order to correct for this and conform to the assumptions of the statistical test, dummy variables were used to mathematically reverse the innovator categories for purposes of this calculation. Table 12 presents the results of the analysis.

Table 12

Reliability Coefficients for Adoption Data

	No. of Items	N	Cases Valid	Excluded	Cronbach's alpha
Site 1	10	39	29	10	.693
Site 2	8	33	29	4	.658
Site 3	8	21	18	3	.747
Site 2 + Site 3 (Merged)	8	53[a]	46	7	.677

[a] Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Cronbach's *alpha* is used to test the reliability of the survey instrument in measuring adoption of technology. Fraenkel and Wallen (2003) suggested that a lenient alpha value of at least .60 is necessary to reject the null hypothesis (H_0= survey questionnaire does not reliably measure adoption of innovative technologies) in exploratory research. Since the alpha variables in the study all exceeded that value, it was concluded that the survey questionnaire reliably measured level of adoption of innovative technologies.

Summary of Results, Research Question 2

The results of the adoption of innovative technologies analyses yielded several interesting facts. First, levels of adoption varied greatly both between individual technologies and between study settings as evidenced by both the large range of values and the very large standard deviations reported. When comparing individual innovative technologies, this variation may be attributable to differences in the technologies themselves. However, when comparing differences between populations (Site 1 to Site 2 for example), these variations might also be caused by differing interpretations of the survey questions that asked for the "number of occasions" each technology was used during the previous semester. Based on the fact that a semester is approximately 100 days long, the range of adoption values for Computer Labs at Site 1 (from 0 to 500 occasions) when compared to Site 2 (from 0 to 40 occasions) may just as likely have been caused by actual level of usage than by teachers interpreting "number of occasions" as "class periods" at Site 1 and "school days" at Site 2. The existence of the possibility of differing interpretations in each study site further supported treating each site as an independent population.

The divergence of measures of central tendency, distribution of adoption values visualized in the histograms, skewness, kurtosis, and Shapiro-Wilks *W* test all led to the conclusion that that these data were not normally distributed. This finding directly impacted the selection of analytic techniques employed to answer the remaining research questions.

The use of Cronbach's *alpha* revealed that the survey questionnaire reliably measured level of adoption of innovative technologies. The results of this *post hoc* test of reliability provided evidence to begin to validate the study methodology, including the development and use of customized instrumentation to collect data from diverse, independent populations identified and discussed in Research Question 1.

The fact that variations in level of adoption existed for all technologies in all settings bore credence to the supposition that these technologies exhibited some level of innovativeness, since they were not routinely used by all teachers. Likewise, the fact that many teachers at each site reported not using the technologies at all supported the major assumption of the research project, that innovative technologies are indeed underutilized by at least some teachers.

Research Question 3

What was the level of access to social capital by the teachers in the study setting?

This question was evaluated through the use of a complex variable, constructed from the response to three individual questions on the survey questionnaire. To determine how often the teachers received help from their colleagues for each technology, participants were asked to name all of the persons who provided such help, along with the number of occasions on which this occurred (for specifics of the questions used, see Appendix D). Since the respondent often reported more than one person, the number of occasions was summed to yield a measure of help received. Details of the construction of this variable are discussed in the methodology section at length.

To determine how often the teacher helped others use technology, participants were asked to name all of the persons who they helped learn to use each innovative technology identified at the study site. The value was then modified by multiplying by the teacher's level of adoption for the identified technology to account for that teachers' expertise in using the technology. Again, multiple responses meant that the researcher had to sum the responses.

Access to social capital was calculated for each technology by multiplying the amount of help received by the amount of help given. These numbers and calculations were recorded on the survey questionnaire and entered into the data set as a single value.

Table 13 summarizes the access to social capital measure for each technology at each site, as well as the total level of access to social capital for each site.

Table 13

Access Social Capital by Teachers

	Technology 1		Technology 2		Technology 3		Technology 4[b]		Total Level of Access to Social Capital	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Site 1	543.26	1872.40	282.46	1041.45	758.69	1715.32	--	--	1584.41	3152.80
Site 2	608.91	1712.26	1705.85	2883.03	339.91	713.49	--	--	2654.67	4443.55
Site 3	1418.33	1684.55	829.14	1247.83	165.05	408.39	--	--	2412.52	2488.74
Site 2+3 Merged	941.08	1743.75	1379.15	2427.43	273.53	620.34	--	--	2593.75	3806.14

[a]Four technologies were identified at Site 1, while only 3 were used at sites 2 and 3.
[b]Value for Technology 4 was dropped from analysis. See discussion below

Interestingly, Site 1 demonstrated the lowest mean level of access to social capital ($\bar{x}$ = 1618.56) even though it showed the highest level of adoption of innovative technologies. Access to social capital for the individual technologies ranged from a high ($\bar{x}$ = 1715.32) for Technology 3 (digital and video cameras) at Site 1 and a low of ($\bar{x}$ = 165.05) for Technology 3 at Site 3 (Dukane DVD/VHS System).

After data were collected, during the data entry process, a data collection error was identified on the Site 1 surveys, resulting in no usable data being collected on teachers providing help to others on the use of Technology 4 (LCD projectors). Therefore, the access to social capital values for this technology were not calculated for Technology 4 (LCD projectors) at Site 1 and are not reported for this innovative technology in any of the following analyses.

Several factors contributed to this decision. First, the LCD projectors used by teachers are part of the document camera (ELMO) system, and some of the teachers' access to social capital related to its use may have been captured by analysis of that innovative technology. Participants reported relatively low levels of usage for this technology ($\bar{x}$ = 19.29 occasions, s=19.59). Only 12 respondents (31%) reported receiving help using this technology, all of them from a single colleague. Of these 12 respondents, nine reported receiving assistance from the building media specialist. These factors made it likely that few participants (approximately four) would have reported providing help to their colleagues.

The researcher was cautious about making any inferences based on observations at this level due to the multiplicative nature of this construct variable. Inherent in the way this variable was calculated are a very large range among reported values and huge variances, as witnessed by the large standard deviations observed. Just as with the level of adoption data, teacher's access to social capital required further analysis to determine its suitability for various statistical analytic techniques.

As with the adoption of innovative technology data, skew and kurtosis values (Table 14), and histograms (Appendix N, Figure N-2) were prepared for the data. Figure 16 presents a representative example of these histograms.

Table 14

Skew and Kurtosis Values for Access to Social Capital Data

	N		Skewness		Kurtosis	
	Valid	Missing	Statistic	Std. Error	Statistic	Std. Error
Site 1						
Document Camera (ELMO)	39	0	5.173	.378	28.796	.741
Computer Labs	39	0	5.329	.383	30.359	.750
Digital and Video Cameras	39	0	2.275	.378	4.271	.741
Total Access to Social Capital	39	0	3.605	.378	16.178	.741
Site 2						
Promethean Boards	33	0	4.074	.409	18.719	.798
Dukane DVD/VHS	33	0	2.357	.409	4.799	.798
Mobile Computer Labs	33	0	2.879	.409	9.257	.798
Total Access to Social Capital	33	0	3.437	.409	14.151	.798
Site 3						
Promethean Boards	21	0	.718	.501	-.953	.972
Dukane DVD/VHS	21	0	2.509	.501	7.568	.972
Mobile Computer Labs	21	0	2.482	.501	5.068	.972
Total Access to Social Capital	21	0	3.333	.501	11.850	.972
Site 2 + Site 3 (Merged)						
Promethean Boards	53[a]	0	2.513	.327	7.949	.644
Dukane DVD/VHS	53[a]	0	2.786	.327	7.697	.644
Mobile Computer Labs	53[a]	0	3.067	.327	11.038	.644
Total Access to Social Capital	53[a]	0	3.378	.327	15.771	.644

[a]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

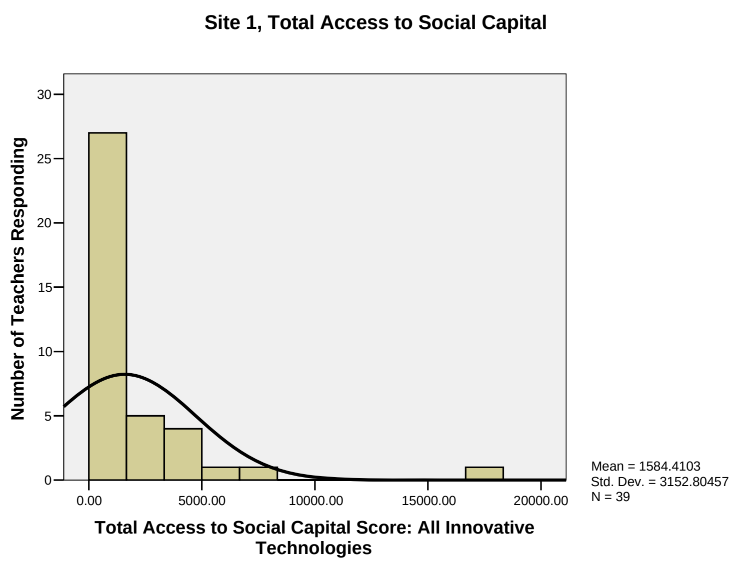


Figure 16. Representative example of a histogram for access to social capital data.

Apparent from this analysis was the strong negative skew the data exhibited, as well as high peaks and strong tails visible on the histograms that manifested as high kurtosis values. Both skew and kurtosis values were very large—more than twice the value of the standard error. With the exception of the Promethean Boards (Technology 1 at Site 3), these observations suggested a non-normal distribution to the data. Further analysis was needed to verify the normality of these data. The Shapiro-Wilk *W* test was chosen for its power with small samples—up to approximately 50 (Myers & Well, 2003, p. 185). Table 15 presents the results of the normality analysis.

Table 15

Shapiro-Wilks W Test for Normality for Access to Social Capital Data

		W	*d.f.*	*Sig.*
Site 1				
	Document Camera (ELMO)	.317	39	.000**
	Computer Labs	.302	39	.000**
	Digital and Video Cameras	.512	39	.000**
	Total Access to Social Capital	.552	37	.000**
Site 2				
	Promethean Boards	.413	33	.000**
	Dukane DVD/VHS	.611	33	.000**
	Mobile Computer Labs	.556	33	.000**
	Total Access to Social Capital	.596	33	.000**
Site 3				
	Promethean Boards	.793	21	.001**
	Dukane DVD/VHS	.688	21	.000**
	Mobile Computer Labs	.460	21	.000**
	Total Access to Social Capital	.873	21	.011*
Site 2 + Site 3 (Merged)				
	Promethean Boards	.613	53[a]	.000**
	Dukane DVD/VHS	.588	53[a]	.000**
	Mobile Computer Labs	.515	53[a]	.000**
	Total Access to Social Capital	.658	53[a]	.000**

[a]iDscrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
*Significant at the α=.05 level
**Significant at the α=.01 level

Based on these results, the null hypothesis (H_0= access to social capital data is normally distributed) was rejected and a conclusion was drawn that the data were best suited to statistical analytical techniques not dependent on the assumption of normality.

Other Measures of Access to Social Capital

Additional data were collected in order to examine teacher's access to social capital. In particular, two questions on the survey questionnaire were used in an attempt to gather this data. The first asked teachers to self-assess the degree to which their colleagues' help allowed them to use the innovative technologies in their classrooms using a 5-point Likert scale. Table 16 summarizes those results. The second asked teachers to self-assess the degree to which they believed that their assistance helped others to use the innovative technologies in the classroom. Table 17 summarizes those results. Last, the a measure of social capital was created by multiplying the "help received" rating by the "help given" rating, consistent with the multiplicative method of calculating the access to social capital scores. Table 18 summarizes those results. See the sample instrument in Appendix D for the exact questions asked and the responses available to respondents.

Table 16

Summary of Help Received Self-Assessment Data

	N		Range		Mean		Median	Mode
	Valid	Missing	Min	Max	$\bar{x}$	s		
Site 1								
Document Camera (ELMO)	39	0	1	5	2.33	1.305	2.00	2.00
Computer Labs	39	0	1	5	2.18	1.211	2.00	2.00
Digital and Video Cameras	35	4	1	5	2.60	1.218	2.00	2.00
Mean Help Received	39	0	1	5	2.34	1.163	2.00	2.00
Site 2								
Promethean Boards	29	4	1	5	3.59	1.476	3.00	5.00
Dukane DVD/VHS	32	1	1	5	2.69	1.176	2.00	2.00
Mobile Computer Labs	30	3	1	5	2.90	1.296	2.50	2.00
Mean Help Received	32	1	1	5	2.97	1.106	3.00	3.00
Site 3								
Promethean Boards	18	3	1	5	1.89	1.079	2.00	1.00
Dukane DVD/VHS	19	2	1	5	2.21	1.032	2.00	2.00
Mobile Computer Labs	16	5	1	5	3.13	1.500	3.00	2.00[a]
Mean Help Received	19	2	1	3.67	2.39	.788	2.33	2.00
Site 2 + Site 3 (Merged) [b]								
Promethean Boards	46	7	1	5	2.98	1.556	3.00	5.00
Dukane DVD/VHS	50	3	1	5	2.54	1.129	2.00	2.00
Mobile Computer Labs	45	8	1	5	3.02	1.340	3.00	2.00
Mean Help Received	50	3	1	5	2.79	1.009	2.67	3.00

[a]Multiple modes exist, lowest value reported.

[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings

Table 17

Summary of Help Given Self-Assessment Data

	N		Range		Mean		Median	Mode
	Valid	Missing	Min	Max	$\overline{x}$	s		
Site 1								
Document Camera (ELMO)	38	1	1	5	2.71	1.183	3.00	3.00
Computer Labs	39	0	1	5	2.51	1.189	3.00	3.00
Digital and Video Cameras	35	4	1	5	2.97	1.043	3.00	3.00
Mean Help Given	39	0	1	5	2.69	1.000	2.75	3.00
Site 2								
Promethean Boards	29	4	1	5	2.67	1.047	3.00	2.00
Dukane DVD/VHS	33	0	1	5	2.88	1.147	3.00	3.00
Mobile Computer Labs	30	3	1	5	3.13	1.187	3.00	3.00
Mean Help Given	33	0	1	5	2.91	.939	3.00	3.00[a]
Site 3								
Promethean Boards	15	6	1	4	4.10	1.165	5.00	5.00
Dukane DVD/VHS	16	5	1	5	3.28	1.179	4.00	4.00
Mobile Computer Labs	15	6	1	5	4.05	1.317	5.00	5.00
Mean Help Given	17	4	1	4	3.84	.884	4.00	4.67
Site 2 + Site 3 (Merged) [b]								
Promethean Boards	43	10	1	5	3.28	1.161	3.00	3.00
Dukane DVD/VHS	48	5	1	5	2.83	1.191	3.00	3.00
Mobile Computer Labs	44	9	1	5	3.30	1.212	3.00	3.00
Mean Help Given	49	4	1	5	3.06	1.016	3.00	3.00

[a]Multiple modes exist, lowest value reported.

[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings

Table 18

Summary of Social Interaction Construct Data

	N		Range		Mean		Median	Mode
	Valid	Missing	Min	Max	$\bar{x}$	s		
Site 1								
Document Camera (ELMO)	38	1	1	25	6.92	5.966	4.00	4.00
Computer Labs	39	0	1	25	5.69	5.172	4.00	3.00[a]
Digital and Video Cameras	33	6	2	25	8.27	6.286	6.00	4.00[a]
Social Interaction	39	0	1	25	6.81	5.457	5.00	500
Site 2								
Promethean Boards	27	6	1	25	13.00	7.957	9.00	9.00
Dukane DVD/VHS	32	1	1	25	7.53	5.291	7.00	4.00[a]
Mobile Computer Labs	29	4	1	25	10.07	7.101	9.00	4.00[a]
Social Interaction	32	1	1	25	9.33	5.279	8.78	7.00[a]
Site 3								
Promethean Boards	17	4	1	25	6.35	5.396	5.00	4.00
Dukane DVD/VHS	17	4	1	25	7.41	5.580	6.00	6.00
Mobile Computer Labs	15	6	1	25	11.60	8.236	9.00	6.00
Social Interaction	17	4	1	14.67	7.26	4.004	6.67	4.00[a]
Site 2 + Site 3 (Merged) [b]								
Promethean Boards	41	12	1	25	10.24	7.690	9.00	4.00[a]
Dukane DVD/VHS	47	6	1	25	7.64	5.379	8.00	4.00[a]
Mobile Computer Labs	42	11	1	25	10.33	7.281	8.50	6.00
Social Interaction	48	5	1	25	8.77	4.856	7.75	4.00

[a]Multiple modes exist, lowest value reported.
[b]Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings

The primary reason these data were collected was to establish the ability of the survey instrument to reliably measure access to social capital by teachers at the study site. To do so, Cronbach's *alpha* (Fraenkel & Wallen, 2003, p. 168) was calculated for each technology at each site, using the individual access to social capital data, individual social interaction scores, total social capital data, and total social interaction scores. Unfortunately, the self-assessment variables are opposite in direction, with higher levels of access to social capital equating to lower scores on the social interaction self-assessment. In order to correct for this and conform to the assumptions of the statistical test, dummy variables were used to mathematically reverse the social interaction categories for purposes of this calculation. Table 19 presents the results of the analysis.

Table 19

Reliability coefficients for adoption data

	No. of Items	N	Cases Valid	Excluded	Cronbach's alpha
Site 1	10	39	33	6	.639
Site 2	8	33	27	6	.687
Site 3	8	21	14	7	.639
Site 2 + Site 3 (Merged)	8	53[a]	39	14	.674

[a] Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Cronbach's *alpha* is used to test the null hypothesis: H_0 = survey questionnaire does not reliably measure access to social capital. Fraenkel and Wallen (2003) suggested that a lenient alpha value of at least .60 was necessary to reject the null hypothesis in exploratory research. Since the alpha variables in the study all exceeded that value, it was determined that the survey questionnaire reliably measured access to social capital by teachers in the study.

Summary of Results, Research Question 3

Several findings again emerged from the analysis of access to social capital at each site. First, levels of access to social capital varied greatly, both between individual technologies and between study settings as evidenced both by the large range of values and by the very large standard deviations reported. Multiple factors (variables) influence access to social capital, with each variable contributing an inherent variability and sampling error. The construction of the access to social capital variable multiplies these variations.

Once again, the divergence of measures of central tendency, distribution of access to social capital values visualized in the histograms, skewness, kurtosis, and Shapiro-Wilks *W* test all led to the conclusion that these data were not normally distributed. Therefore, future analysis would require the use of statistical techniques robust to the violation of this assumption.

The results of the Cronbach's *alpha* revealed that the survey questionnaire reliably measured access to social capital by teachers at all study sites. As discussed in Research Question 2 above, this also helped to validate the methodology and use of customizable instrumentation at each study site.

Variations existed in the access to social capital reported by teachers both within and between study populations. Based on the work of Frank et al. (2004), who suggested that variations in access to social capital may be responsible for the observed differences in adoption of innovative technologies, this observation was used as justification for conducting an analysis of the relationship between these variables (Research Question 6) as well as to validate the definition of each study site as an independent sample in the investigation.

Research Question 4

Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of technology adoption?

Initially, the survey was set up to collect data used to differentiate between two groups based on gender (male or female) and assignment (academic or elective). Due to the makeup of the samples, a third variable, grade level (elementary or middle school), was added to detect differences between these groups as well. Table 20 describes the distribution of grouping variables—gender, assignment and grade level—at the study sites.

Table 20

Distribution of Grouping Variables at Study Sites

		Gender		Assignment		Grade Level	
	N	Female	Male	Elective	Academic	Elementary	Middle
Site 1	39	30	9	12[b]	18[b]	6	33
Site 2	33	25	8	14	19	--	33
Site 3	21	21	--	15	6	21	--
Site 2 + Site 3 (Merged)[a]	53	45	8	34	19	33	20

[a] Discrepancy in total due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
[b]Values reflect missing responses on some surveys.

Since the assumption of normality for level of technology adoption was determined to have been violated, the nonparametric Mann-Whittney *U* test was selected to detect differences between the groups. Table 21 presents the results of this analysis.

Table 21 *Mann-Whittney U Test of Adoption Means between Groups*

		Gender		Assignment		Grade Level	
	N	*U*	Sig.	*U*	Sig.	*U*	Sig.
Site 1	39	117.000	.548	68.500	.094	98.000	.969
Site 2	33	95.000	.833	132.500	.985	-- [b]	-- [b]
Site 3	21	--	--	16.000	.023*	-- [b]	-- [b]
Site 2 + Site 3 (Merged)[a]	53	154.500	.525	263.500	.268	202.000	.018*

[a] Discrepancy in N due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
[b] Unable to perform analysis due to only a single group at the study site.
*Significant at the α = .05 level

The results of the non-parametric tests revealed only two significant differences (α = .05) between groups. The first was between academic and elective teachers at Site 3. However, even though a non-parametric test was used, the small N (21) and small cell size (only six academic teachers in one of the groups) cast some doubt on the validity of that result. The second significant difference was between elementary and middle school teachers using the merged data for Sites 2 and 3. The researcher noted that significant differences did not exist between these groups in the unmerged data, since Site 2 is entirely a middle school and Site 3 entirely an elementary.

Summary of Results, Research Question 4

The non-parametric Mann-Whittney *U* test detected statistically significant differences between academic and elective teachers at Site 3 as well as between elementary and middle school teachers using the Site 2 and 3 merged data. These results might be explained by small sample size (N = 21) at Site 3 and the fact that data were collected at two different times in the merged data set. Because there was no pattern of significant differences across the study populations, it was concluded that none of these variables constituted a confounding variable when examining the relationship between adoption of innovative technologies and access to social capital by teachers.

Research Question 5

Did various sub-groups of teachers based on gender (male versus female), assignment (academic versus elective), or grade level (elementary versus middle school) exhibit different levels of access to social capital?

The same groups that were used to examine patterns of adoption of innovative technologies were also employed in an effort to answer this question. Likewise, the same Mann-Whittney *U* test was used to test for significant differences between means at each study site. Table 22 presents the results of the non-parametric test.

Table 22

Mann-Whittney U Test of Social Capital Means between Groups

		Gender		Assignment		Grade Level	
	N	*U*	Sig.	*U*	Sig.	*U*	Sig
Site 1	39	123.000	.680	56.500	.023*	67.000	.200
Site 2	33	90.000	.672	128.000	.854	--[b]	--[b]
Site 3	21	--[b]	--[b]	17.000	.026*	--[b]	--[b]
Site 2 + Site 3 (Merged)[a]	53	161.000	.623	259.500	.233	315.000	.781

[a] Discrepancy in N due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
[b] Unable to perform analysis since only a single group present at study site.
*Significant at the α = .05 level

The results of the non-parametric tests revealed two significant differences (α = .05) between groups. Academic and elective teachers exhibited different levels of access to social capital at Sites 1 and 3. However, two factors may have contributed to these findings. First, at Site 1, nine teachers out of 39 (23%) neglected to provide this data. This error in sampling may contribute significant error to the analysis. Second, there were only six elective (extended core) teachers at Site 3. This small cell size likewise casts doubt on the validity of this result.

Summary of Results, Research Question 5

Two significant differences were detected between academic and elective teachers at Sites 1 and 3 by the non-parametric Mann-Whittney *U* test. The small number of elementary teachers (n = 6) at Site 1 and the small population size (N = 21) at Site 3 cast serious doubt on the validity of these result. It is likely that these findings are the result of sampling error rather than actual differences between groups. Therefore, it was concluded that none of these variables represented a confounding variable in examining the relationship between level of adoption of innovative technologies and access to social capital by teachers.

Research Question 6

Did a relationship exist between teachers' access to social capital and level of adoption of innovative technologies in the study setting?

This was the primary question posed to examine the research problem. Initial scatter plots of the data (Appendix N, Figure N-3) suggested that a linear relationship might exist between the research variables. Figure 17 is a representative example of those scatter plots. Visual inspections of these scatter plots revealed the existence of numerous extreme or outlier variables in the data.

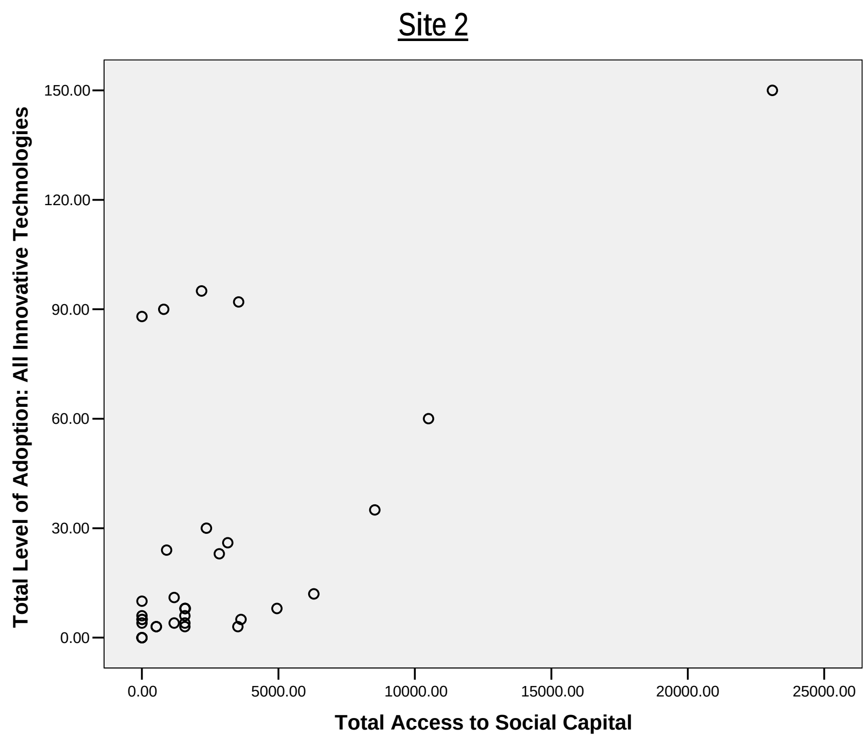


Figure 17. Representative example of scatter plot: Adoption and access to social capital.

Before investigating any relationship between the research variables, it was necessary to examine the extreme values present in the data and determine if they accurately represented the level of adoption of innovative technologies and teachers' access to social capital, or whether they represented errors in data collection and therefore needed to be eliminated from the data as outliers. The original surveys were reviewed, the respondents' answers checked, and the adoption and social capital variables re-calculated. No errors were detected in the coding of data. Similarly, those surveys were compared to the electronic database and verified for accuracy. Again, no error in data entry was detected.

Based on this analysis, it was determined that the extreme values in the data accurately represented the adoption of innovative technologies and teachers' access to social capital. Support for these extreme values can be found in Rodgers (1985) definition of “innovators,” who represent those technology users who adopt technologies two or more standard deviations from the mean (see Figure 18). According to this model, a few extreme values should exist in any group of technology adopters, representing this small but influential group of technology innovators.

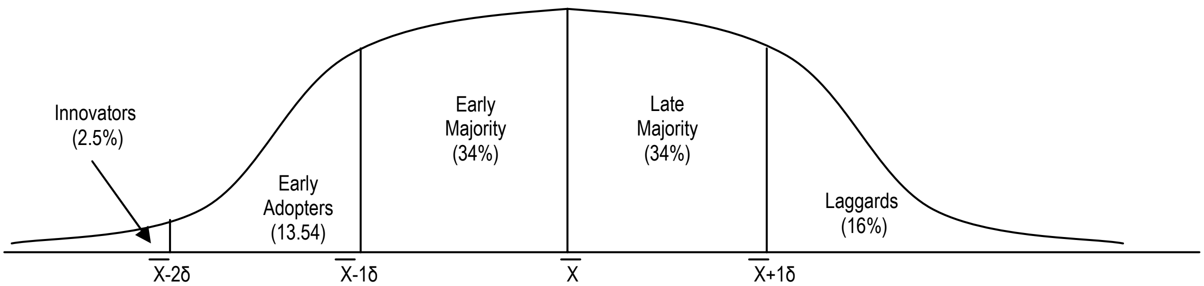


Figure 18. Rodgers (1985) innovator categories.

In order to explore any potential relationship between these variables, a correlation coefficient needed to be calculated. Since neither the dependent variable (level of adoption of innovative technologies) nor the independent variable (level of access to social capital by teachers) were normally distributed, Spearman’s *rho* (rank-order correlation coefficient—r_s) was used to examine the data. Myers and Well (2003) pointed out that “…[the Spearman *rho* coefficient] diminishes the importance of extreme scores” (p. 48). Both variables of interest exhibited significant negative skew, implying that such extreme scores exist in the data, and providing support for the decision to use this analysis technique. Table 23 reports the results of the correlation analysis for all technologies at each site, as well as the aggregate value for each technology at each site.

Table 23

Correlational Analysis: Adoption and Access to Social Capital

	N	Spearman's r_s	Spearman's Sig.
Site 1			
Document Camera (ELMO)	39	.508	.001**
Computer Labs	39	.226	.172
Digital and Video Cameras	39	.384	.016*
Total Social Capital	39	.350	.029*
Site 2			
Promethean Boards	33	.682	.000**
Dukane DVD/VHS	33	.632	.000**
Mobile Computer Labs	33	.765	.000**
Total Social Capital	33	.541	.001**
Site 3			
Promethean Boards	21	.665	.001**
Dukane DVD/VHS	21	.415	.061
Mobile Computer Labs	21	.640	.002**
Total Social Capital	21	.643	.002**
Site 2 + Site 3 (Merged)			
Promethean Boards	53	.618	.000**
Dukane DVD/VHS	53	.587	.000**
Mobile Computer Labs	53	.727	.000**
Total Social Capital	53	.563	.000**

*Significant at the α=.05 level
**Significant at the α=.01 level

Summary of Results, Research Question 6

Results from the statistical tests clearly showed a strong, positive correlation between level of adoption of innovative technologies and teachers' access to social capital. Nearly all the comparisons were significant at least the .05 level. Remarkably, given the relatively small sample size, a majority of the significant correlations were, in fact, significant at the .01 level. Only two technologies exhibited no significant correlation: The use of computer labs at Site 1 (r_s = .226, Sig. = .172) and the Dukane DVD/VHS system at Site 3 (r_s = .425, Sig. = .061). Since the second of these was nearly significant, and the population size was fairly small (N = 23), it is possible that this finding is the result of Type II error rather than an actual difference in the relationship between the variables.

Based on the results of the correlational analysis, the researcher concluded that, with the exception of the use of computer labs at Site 1, a statistically significant relationship did indeed exist between level of adoption of innovative technologies and teacher's access to social capital. The discrepancy with computer labs may have been caused by any number of factors. Perhaps computer labs are not particularly innovative, or many teachers already used them prior to the test period. However, without a metric to measure these assumptions, such analysis is purely speculative. Since the rest of the findings in three different study settings, as well as three other technologies in the building, all support the existence of a relationship between adoption of innovative technologies and teachers' access to social capital, it appears that the computer labs at Site 1 were not perceived to be an innovative technology that would be impacted by social capital.

Research Question 7

Did a relationship exist between several potentially confounding variables (age, experience, on-site experience) and level of innovative technology adoption by teachers in the study setting?

Given the relationship between level of adoption of innovative technologies and access to social capital by teachers, the researcher was able to investigate the possibility that several potential confounding variables may also have influenced level of adoption of innovative technologies. Data were collected on three such variables: teachers' age, the number of years they had been teaching (experience), and the number of years assigned to the study setting (on-site experience). Histograms of all potential confounding variables (Appendix N, Figure N-4) were created. Figure 19 is a representative sample of such a histogram.

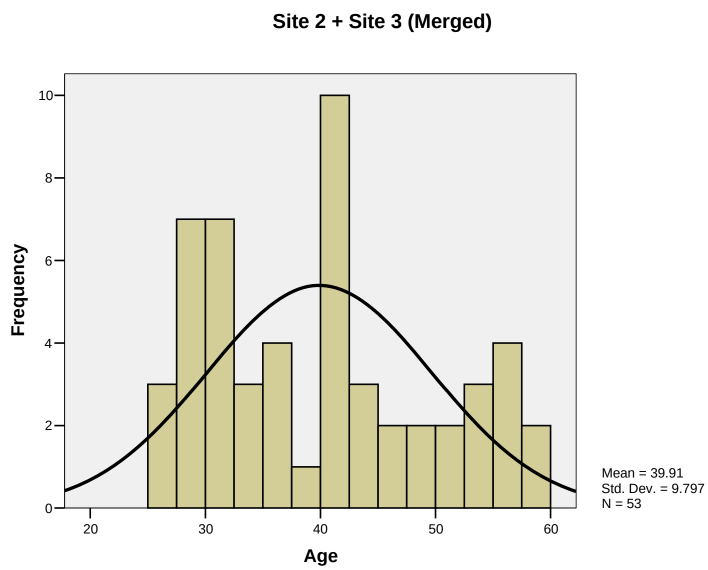


Figure 19. Representative histogram of possible confounding variables and adoption.

Table 24 reports the distribution of each potential confounding variable at each study site. Additionally, the Shapiro-Wilk *W* statistic was calculated as a test for normality for each variable.

Table 24

Distribution of Potentially Confounding Variables

	N		Range		Mean		Median	Mode	Normality	
	Valid	Missing	Min	Max	$\bar{x}$	s			*W*	Sig.
Site 1										
Age	36	3	23	52	35.64	7.69	33.5	33	.927	.020*
Experience	39	0	0	22	8.05	5.33	8	3	.941	.054
On-Site	39	0	0	11	3.10	3.24	3	0[b]	.835	.000**
Site 2										
Age	33	0	25	58	42.18	9.94	42	32[b]	.952	.148
Experience	33	0	1	36	12.82	9.64	9	9	.909	.009**
On-Site	33	0	0	4	2.27	1.27	3	3	.858	.001**
Site 3										
Age	21	0	27	56	36.86	8.90	37	28	.882	.016*
Experience	21	0	1	28	9.57	6.96	8	6	.894	.027*
On-Site	21	0	0	4	2.38	1.28	3	3	.812	.001*
Site 2+Site 3 (Merged) [a]										
Age	53	0	25	58	39.91	9.80	40	43	.936	.007**
Experience	53	0	1	36	11.47	8.83	9	3[b]	.890	.000**
On-Site	53	0	0	4	2.30	1.27	3	3	.842	.000**

[a] Discrepancy in N due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.
[b] Multiple modes exist, lowest value reported.
*Significant at the α = .05 level
**Significant at the α = .01 level

As expected, nearly all the potential confounding variables were normally distributed at an α = .05 level. The only exceptions were age at Site 2 and experience at Site 1 (though it was nearly significant). These results were probably due to the relatively small population sizes (N = 39 and N = 21, respectively). Because the potentially confounding variables were normally distributed but the level of adoption of innovative technologies was not, Spearman's *rho* was again selected to determine if a relationship existed between the variables. Table 25 summarizes the results of these analyses. No correlation between any of these variables and level of adoption was found at any of the study sites.

Table 25

Correlational Analysis: Adoption and Potentially Confounding Variables

		N	Spearman's r_s	Sig.
Site 1				
	Age	36	-.037	.828
	Experience	39	-.090	.854
	On-Site	39	.182	.269
Site 2				
	Age	33	.110	.541
	Experience	33	.030	.869
	On-Site	33	.238	.183
Site 3				
	Age	21	-.049	.832
	Experience	21	-.193	.401
	On-Site	21	.141	.542
Site 2 + Site 3 (Merged) [a]				
	Age	53	.190	.172
	Experience	53	.046	.742
	On-Site	53	.197	.157

[a] Discrepancy in N due to one teacher submitting identical questionnaires at both sites due to their assignment to both buildings.

Summary of Results, Research Question 7

Based on results of this analysis, it was concluded that no statistically significant relationship existed between any of the potentially confounding variables and level of adoption of innovative technologies at the .05 level. This meant that, while a statistically significant relationship existed in every study setting between access to social capital and the level of adoption of innovative technologies, no such relationship was detected for more common factors drawn from diffusion of innovation literature. This finding supported the basic premise of the research that access to social capital was not only a contributory factor to adoption of innovative technologies, but in fact the primary factor in the adoption process.

Research Question 8

Did a relationship exist between several potentially confounding variables (age, experience, on-site experience) and level of innovative technology adoption by teachers in the study setting?

Only three cases were detected where a confounding variable had an effect on one of the study variables (Table 26).

Table 26
Significant Confounding Variables (α = .05)

	Significant Confounding Variables
Site 1	Grade Level (Social Capital)
Site 2	None
Site 3	Assignment (Social Capital)
Site 2 + Site 3 (Merged)	Grade Level (Adoption of Technology)

Note: Parentheses indicate variable affected by confounding variable.

As discussed in the appropriate sections above, the validity of each of these findings is suspect based on small sample size, sampling error, or other reasonable explanations. Therefore, while statistically significant, they were rejected as confounding variables for purposes of evaluating the relationship between adoption of innovative technologies and access to social capital by teachers.

Summary of Results, Research Question 8

Since none of these variables was consistent across all study sites, technologies, or study variables, and evidence existed that questions the validity of the finding of significance, it was determined that there were no confounding variables that impacted the overall relationship between access to innovative technologies and teachers' access to social capital in the study. Because no meaningful, significant factors were identified, that could not be explained away sampling and data collection errors, no further analysis of the relationship between research variables was necessary.

Discussion

Few would argue the fact that good research is the product of quality data and appropriate statistical analysis. Just as important, however, is the careful consideration of assumptions made and existing limitations. The following is a brief discussion of these considerations as they pertain to the more important findings from the research study.

Site Selection and Instrument Customization

The sample used in the research was limited by feasibility, access, and suitability of the site for data collection. The study was further limited by the methodology used to collect data. While it was established that the survey questionnaire was valid during the instrument development process, the data generated may have been more prone to bias based on self-response than data collected via more direct observational methods. On the other hand, the use of survey methods did allow the researcher to collect data from a larger number of participants in a short time period. In all, the chosen methodology provided a reasonable balance between the need for a manageable sample size while still controlling for as many other variables as possible.

A concerted effort was made to locate a suitable instrument prior to beginning the research. Several potential instruments related to the investigation of technology adoption or access to social capital were found. One promising questionnaire was the Teaching with Technology Instrument (TTI; Atkins & Vasu, 1998). According to the authors, the instrument was intended to help plan for professional development of teachers by measuring their knowledge and use of technologies. However, after review of the instrument, the researcher determined that the instrument was better suited to assessing teachers' *knowledge* of the use of technology, rather than documenting their actual level of adoption. Grootaert et al. (2004) presented the Integrated Questionnaire for the Measurement of Social Capital (SC-IQ). The purpose of the survey was "to provide a core set of survey questions for those interested in generating quantitative data on various dimensions of social capital as part of [other surveys]" (p. 1). Upon review of the questionnaire, it became obvious that the questions were far better suited to examining patterns of social capital at the national level, taking into account a sample drawn from all segments of the populations. It became clear that, while the instrument could differentiate between groups from different backgrounds, nationalities, income levels, or other socio-economic classes, it was ill-suited to detect differences in access to social capital in the somewhat homogenous micro-segment of the population represented by teachers in the study setting.

Since innovative technologies within a particular district was the focus of the research, no existing instrument offered the unique cross section of technologies targeted by this study. In addition, the measurement of social capital was also unique at each site. The instrumentation used by Frank et al. (2004) was the most promising but, again, not specific enough to address the exact research questions posed. However, it did serve as a foundation upon which one could base the questions of a custom survey. Rather than writing entirely new questions, slight modifications of the questions in the Frank et al. survey were used to more specifically address the particular technologies and details of social interactions necessary to collect data at each site.

Last, the use of a custom instrument for each study setting prohibited reliability testing of the instrument before it was administered. Therefore, data were collected on the instrument using different questions to evaluate the research variables. This allowed for the calculation of a reliability statistic (Chronbach's alpha) in a *post hoc* test of reliability. In essence, each survey represented a pilot study. However, the repetition of the instrument customization process in multiple settings, coupled with the finding of *post hoc* reliability, served to provide some validation of the instrument customization *process*, if not the actual survey instrument.

In summary, several technologies were identified as innovative at each study site based on a structured interview and used to customize a survey instrument for each setting. Data were collected from each site and used to examine both teachers' level of adoption of those innovative technologies as well as their access to social capital. The data for each of these variables exhibited noteworthy variation and non-normal distribution. Minimal differences between differing groups of teachers were detected, which could be explained by sampling error. A *post hoc* test was used to determine that the customized survey instrument reliably measured each of the research variables. A statistically significant correlation between level of adoption of innovative technologies and teachers' access to social capital was also detected. However, none of the potentially confounding variables tested were determined to modify the relationship between the research variables.

Chapter 5: Summary, Conclusions, and Recommendations

This chapter summarizes the research conducted and findings that emerged. Conclusions are drawn from those findings. Also included are the implications of the findings for teachers, administrators, and technology leaders in schools. Finally, recommendations for further research are presented.

Summary

This research project began with the observation that teachers in the United States are provided with access to a variety of innovative technologies that promise to improve their teaching practice. In examining the use of these technologies, previous research had shown that, despite this access, teachers were slow to adopt these technologies. Typically, these researchers drew on *diffusion of innovation* and *social network* theory to examine the potential cause of this lag in adoption. Emerging from this research, teachers' *access to social capital* was identified as a promising contributory factor. However, little research could be identified that specifically explored this link between access to social capital and adoption of innovative technologies in schools. Therefore, this research study sought to empirically explore these two variables and evaluate any relationship between them.

In order to conduct the investigation, data were gathered from teachers at three schools located in two buildings within a single school district. Qualitative data were obtained through structured interviews to identify potentially innovative technologies and to customize a survey instrument (adapted from Frank, et al., 2002) to examine those technologies at each individual site. Quantitative data collected via these survey instruments was then used to characterize and evaluate both the level of adoption of each innovative technology and teachers' access to social capital. Further statistical analysis was conducted to establish that a relationship existed between these factors. Last, data were collected to examine if several potentially confounding variables contributed to that relationship. Based on addressing the eight formal research questions posed by the researcher, several important findings and understandings emerged from the study and are presented below.

Using the data collected during the innovative technology identification meetings, it was established that multiple innovative technologies existed in each study setting. While many such innovative technologies were present at each site—as would be expected within a single school district—it was noted that some variation among those innovative technologies also existed. This was important in that, since the specific technologies differed from site to site, it could be established that each site represented a unique and independent population, and therefore data and results from one site could not be combined with other sites to represent a larger, general population.

When examining the data on level of adoption of innovative technologies, it was noted that none of the technologies identified were used by all teachers. This provided evidence that these technologies qualified as innovative. More importantly, since these technologies were available to all teachers but not used by all, it was shown that the underutilization of innovative technologies identified as a significant research problem did indeed exist in the study populations.

As predicted by diffusion of innovation theory, variation existed among the level of adoption of innovative technologies by individuals at each site, thereby giving credence to the idea that some factor or factors was contributing to this variation. Because each site represented a unique population and used unique combinations of innovative technologies, the use of a customized instrument was indicated. Due to the fact that each instrument needed to be somewhat unique, it became impossible to identify and use an existing instrument for this purpose. Because of this restriction, the *post hoc* reliability of each instrument was measured using Cronbach's *alpha*. The results of this analysis indicated that the use of customized instruments did reliably measure levels of adoption of innovative technologies at each site.

Analysis of the distribution of adoption of innovation data indicated that it was not normally distributed. This revelation was important in the selection of analysis techniques used later in the study.

Similar findings were uncovered when the teachers' access to social capital was evaluated at each study site. Variations again existed. These data were also not normally distributed. Likewise, the results of Cronbach's *alpha* showed that, even though a customized instrument was used for each study site, those instruments did reliably measure access to social capital.

Both access to social capital and level of adoption of innovative technologies were further examined within a variety of binomial subgroups based on gender (male or female), area of assignment (academic or elective), and grade level (elementary or middle school). Only a few such differences were detected. Upon deeper analysis, it was established that all of these findings were probably due to sampling error and small population sizes and not indicative of actual differences in the study populations. Therefore, based on the research methodology used, it was determined that these variables did not represent statistically significant contributing factors in the context of this study.

Spearman's *rho* (r_s) was the statistical tool used to evaluate the relationship between teachers' adoption of innovative technologies and access to social capital. A significant positive correlation did indeed exist between the research variables.

Three factors gleaned from the literature on diffusion of innovation were tested to see if they might modify this relationship. These factors included age, teaching experience and years working at the study site, all measured in years. Spearman's *rho* (r_s) was again used evaluate the relationship. No statistically significant correlation was found between these potential co-variables and the research variables.

In summary, the methodology allowed for the identification of innovative technologies present in the study settings, as well as the collection of data to reliably and empirically measure the level of adoption of those innovative technologies, and the teachers' access to social capital. A statistically significant positive relationship was found to exist between these variables. Last, no such statistically significant relationship was present when examining factors including age, years of teaching experience, and number of years assigned to the study setting.

Conclusions

Drawing from the findings of the research study, several conclusions about the adoption of innovative technologies and access to social capital by teachers are posed below.

The innovative technology identification teams at all study sites had little difficulty identifying numerous "new" technologies present at each school. Further, the existence of multiple and unique innovations at each site led to the conclusion that teachers are routinely exposed to these innovations.

The analysis of level of adoption of individual innovative technologies yielded two important facts. First, none of the technologies was routinely used by all teachers, supporting the conclusion that these technologies were indeed innovative. Secondly, the variation in levels of adoption allowed one to conclude that many of these technologies were in fact underutilized, as predicted by previous research.

Similarly, it was noted that teachers exhibited differing levels of access to social capital. Furthermore, the variation in access to social capital was positively correlated with level of adoption of innovative technologies. This allowed one to conclude that teachers with higher access to social capital also exhibit higher levels of adoption of innovative technologies. One exception to this conclusion emerged from the results from the analysis of Computer Lab usage at Site 1. This discrepancy led to the conclusion that a more precise definition of innovative technologies and / or level of adoption is desirable for future studies.

The considerable variation noted in both level of adoption of innovative technologies and teachers' access to social capital further suggested that participants' unique interpretations of innovative technologies and/or social capital may have introduced a degree of error into the results. Based on this assumption, it was concluded that more precise definitions and/or explorations of these variables are indicated for inclusion in future research.

In examining this relationship between research variables, variations in access to social capital and level of technology adoption were not present in common subgroups of teachers based on gender, teaching assignment, and instructional level. Furthermore, no relationship between level of adoption and common confounding variables (age, experience and length of assignment) was detected. Based on these findings, social capital was identified as the main contributory factor. Furthermore, none of the potentially confounding variables contributed significantly to the observed variance in level of technology adoption.

Last, and perhaps most important, the existence of the relationship between teachers' access to social capital and level of adoption of innovative technologies yielded the conclusion that actions by change agents in schools aimed at increasing teachers' access to social capital may lead to increased adoption of innovative technologies and therefore more efficient and effective use of scarce resources.

Recommendations

Future studies in a variety of settings will be needed before a comprehensive model explaining the complex relationship between the study variables can be constructed. However, should the relationship between teachers' access to social capital and level of adoption of innovative technologies prove valid in the general population, this understanding promises to be a powerful tool with the potential to aid teachers, administrators, and government policy makers to more efficiently and effectively utilize their innovative technology resources. A discussion of several recommendations follows. Important recommendations have been underlined for emphasis

Recommendations for Teachers

Teachers may stand to benefit the most from the knowledge gained during this study. To do so, they must <u>first recognize that multiple innovative technologies are</u>

present in their workplace. Rather than waiting passively for these technologies to work their way into their daily teaching practice, teachers should look to each other for the help, support, and assistance they need when learning to use those technologies. This will require that they not only tap existing social communication channels but actively seek out new sources of knowledge, help, and support. Additionally, teachers must learn to identify roadblocks to social interaction and work towards removing them, allowing the free flow of expertise to occur. Furthermore, once they learn to use innovative technologies available to them, they must also employ their social network to disseminate that knowledge to other teachers.

Finally, teachers should seek out new technologies and bring them into their buildings, secure with the knowledge that the requisite skills and knowledge necessary to drive the adoption of those innovations reside within the social structure of the school.

These understandings must also be communicated to post-secondary students and pre-service teachers as they prepare to enter the teaching profession. These fledgling teachers potentially represent a great source of social capital based on the specialized, up-to-date, and perhaps "innovative" knowledge, skills, and techniques they possess. When one considers that veteran teachers gain their social capital through experience and social interaction, it is apparent that both new and old teachers can make significant contributions to the adoption of innovation process.

Recommendations for Administrators

Similarly to teachers, administrators must recognize that innovative technologies exist within their schools. They must also recognize that the teachers assigned to the building represent, in and of themselves, change agents who can be empowered to drive the adoption of those innovative technologies. Administrators must also <u>seek to enable the creation of social capital</u>. This might take many forms: scheduling teachers time to interact, creating common meeting areas, devoting professional development time to the transfer of knowledge on the use of innovative technologies, and so on. While a cost—perhaps significant—can be associated with these measures, it can be recouped both in the elimination of outside sources of help, training, and support, as well as through the potential for increased productivity brought about through the use of those technologies.

The social network existing within a school building is a valuable resource. Administrators must strive to <u>lean all they can about their human assets</u> and manage these assets to maximize the impact these actors can apply.

Last, administrators <u>must recognize that they themselves are part of the social network</u> in the school and should also participate in the exchange of knowledge, skills, and support needed to drive the adoption of innovative technologies. Uniquely, administrators are in the position to act as both the facilitators and actors in the adoption process.

Recommendations for Government Policy Makers

Government policy makers must <u>recognize that innovative technologies are widely available in schools</u>. However, it can also be argued that these resources are underutilized. Therefore, these policy makers should shift the focus of their efforts towards driving the adoption of these innovations, rather than on the continual acquisition of new technologies with little or no thought to their deployment. This should include <u>specifying funding for the professional development of teachers</u> in the use of existing technologies. Since this study has shown that teachers' access to social capital is the primary factor in that adoption, these efforts should be directed at increasing that social capital. Such efforts might include support and funding for research on the relationship between adoption of innovative technologies and teachers' access to social capital, increasing the quality and quantity of social interaction among teachers, and providing funding towards removing obstacles to such social interaction.

Suggestions for Further Study

This research study was exploratory in nature. Future research should be conducted to explore the adoption of innovative technologies in schools and teachers' access to social capital. The purpose of these studies should be both to duplicate the findings of this study and to expand the inquiry to pertinent related topics. The following discussion suggests several areas that future researchers might focus on in their exploration of these variables and the relationship(s) between them.

Research Methodologies

In order to validate the findings of this research and potentially expand those findings to the general population, future researchers must repeat this study, both in similar settings and by applying the methodology to related settings—larger schools, colleges, adult education, technical training, and apprenticeship programs, and so on.

Innovative technology identification meetings with key technology policy makers in schools could be used as a stand-alone tool to both identify innovative technologies and plan teacher professional development targeted at improving the usage of those innovations. Likewise, the customized survey methodology used in this study could be used to quickly provide technology leaders with a snapshot of the existing state of adoption of innovations present in school settings.

Further research will also lead to incremental revisions to the survey instrument used in this study. Such improvements might focus on making the instrument more precise and less prone to differences in interpretation. It is unlikely, but possible, that these revisions may eventually lead to a multi-purpose instrument that could be used in any study setting. The advantage to this approach would be increased confidence in the results due to the use of an instrument judged as both valid and reliable prior to its deployment as part of the study.

Larger studies should also be conducted. Besides adding to the predictive power of the results, these studies may provide the opportunity for true random sampling. This in turn may lead to a more normal distribution of data and the ability to use more powerful statistical analytic techniques to investigate the relationship between level of adoption of innovative technologies and teachers' access to social capital.

Innovative Technologies

One interesting finding emerging from this research study was the reported existence of multiple innovative technologies at each site. One possible area of inquiry would focus on studying this phenomenon in multiple sites to establish whether innovative technologies are indeed pervasive in schools today.

It may also desirable to characterize "innovative" in the context of educational technologies. To that end, a comprehensive qualitative investigation of innovations in school settings might be conducted. Such a project should include multiple methods and multiple modes of data collection in an attempt to precisely define what is, and is not, truly innovative in school settings. This understanding would also be useful in future repetitions of this research study, as it would allow the researcher to more precisely customize the survey questionnaire to accurately collect data on adoption of those technologies.

Alternate methods for determining the existence of innovative technologies in schools could also be investigated. Rather than relying on qualitative, self-reported methods as in this study, direct observation, historical research, or physical inventory could provide an objective measure of the technologies present at a research site.

Last, research should focus on the shelf life of technology adoption. It is unlikely that the methodology used in this research study—limiting the exploration of adoption of innovative technologies to a single semester—accurately reflect the actual life cycle of those innovations, from acquisition through initial usage and ending with pervasive adoption or rejection of the technology. It may be more enlightening to identify an innovative technology and follow it through the adoption process, from beginning to end. Such a case study may reveal factors or characteristics of the technology or the teachers that were not captured by this study.

Adoption of Innovative Technologies

Once the existence of innovative technologies has been established, the question of whether or not they are fully utilized emerges. In this study, teachers self-reported their level of usage or each technology. A more precise measurement may be more desirable. Case studies or direct observations could be used to more objectively measure teachers' level of usage of innovative technologies.

Future researchers might use the existing methodology, but define adoption more specifically by more rigorously defining the use of each innovation. Perhaps adoption could be measured in minutes, hours, or days rather than the more vague "occasions."

This might require the use of participant journals, direct observation, or video taping teachers in the classroom to accurately collect such data.

A study that focuses on innovative technologies present in multiple schools, as well as on the intended use of each technology, could be of interest to policy makers. For instance, in this study, the LCD Projectors at Site 1 and the Promethean Boards at Site 2 may serve similar functions. From an economy of scale standpoint, the school district might have been better served to adopt one or the other as standard at all schools, thereby condensing the training, support, and maintenance required.

Teachers' Access to Social Capital

While it is interesting to know that increasing teachers' access to social capital leads to an associated increase in level of adoption of innovative technologies, a deeper understanding of the complex interactions that make up that social capital promises to provide the basis for many future studies. Beyond simply measuring teachers' self-reported interactions, a researcher might conduct one-on-one observations, case studies, or other research to precisely measure such interaction. Furthermore, research should be conducted to uncover other factors that may contribute to social capital—direct interaction, indirect interaction, rank or social standing, cultural or gender norms, and so on.

The researcher feels strongly that future research should also attempt to differentiate between channels of communication to see if any particular method of exchanging knowledge, skills, and support is better suited to increasing the level of adoption of innovative technologies. These might include casual conversation (during breaks), formal conversations (during professional development meetings), electronic communication (email and chat), written communication (training documents) or other factors.

Author's Comments

(Note: Due to the introspective nature of this section, it has been intentionally presented in the first person.) As a teacher/researcher, I have the unique opportunity to bring together my two existing social networks—both academic and professional. This research project represents not only an academic exercise, but an attempt to better understand my own professional practice. There are multiple purposes for this introspective investigation, including a desire to improve my teaching, improve the achievement of my students, and inspire or empower my colleagues to take full advantage of the technological advancements available to them as teachers.

Upon completion of this project, many opportunities have presented themselves to put the knowledge gained from the study into practice. One improvement to my personal professional practice immediately springs to mind. While I consider myself an "early adopter" or "innovator" when it comes to educational technologies, this study has made me realize that there are many innovations available to me personally, that for one reason or another have not found their way into my daily practice. However, I also know that many of my colleagues are using them successfully in their classrooms. It is now incumbent on me to draw on that expertise and learn to incorporate those technologies into my own classroom. Likewise, I need to begin to disseminate the expertise I possess outward to my colleagues—especially those who are somewhat hesitant or resistant to adopting new technologies.

While the pursuit of personal improvement is a meaningful goal, it is in the arena of professional leadership that I feel the knowledge gained from this study will best be employed. By combining suggestions for improved policy and practice, backed by empirical data, it may be possible to convince educators that social interaction is a potentially powerful tool for the improvement of teaching practice. Since social interaction is, by definition, a participatory activity, strong leadership both externally (from administrators and policy makers) and internally (from other teachers) will be needed to encourage all teachers to draw on the expertise latent in their existing social network. A paradigm shift in approach may be needed to make this work. The traditional role of leaders—who set goals, agendas, and procedures for the persons underneath them in the organization—runs counter to the findings of this study. In order to draw on the social network, those leaders must be part of the social network and "lead by example." As a leader, I myself must create a school culture, through my personal actions, in which the free exchange of ideas and expertise are not only encouraged, but required.

By employing the understandings generated by this project, I will continue to grow as a professional. However, the opportunity to grow as a researcher also exists. This study represents only a preliminary step in the understanding of the relationship between access to social capital and adoption of innovative technologies in schools. The results of this study have suggested many new, relevant research questions to me, including questions about the nature of communication within social networks, the definition of innovation as it applies to educational technologies, and the role of leadership in changing school culture. Primarily of interest to me is a deeper investigation of the social networks in school. It appears to me that significant future investigation will be needed to identify, describe, and quantify the many potential factors that influence or impact the creation of social capital by teachers. Only by rigorous examination of these factors can the true nature and potential of these powerful social networks be understood, harnessed, and put to use.

While the repetition of this study in other settings should be undertaken, my next research project will probably focus on a deeper investigation of social networks in schools. Likewise, that research will probably tend towards the action research realm of investigation—the acquisition of knowledge not only for knowledge's sake, but for the improvement of my own professional practice.

Closing Remarks

Increasing teachers' access to social capital leads to an increase in level of adoption of innovative technologies. While seemingly a simple observation, this finding represents the first step in empowering classroom teachers to improve their teaching practice through the use of emerging technologies. In the modern educational climate of increased demands on teachers and shrinking budgets, this promises to be not only an effective tool, but relatively inexpensive to implement. It is no longer acceptable to simply provide teachers with new technologies with little or no thought given to teaching them how to use them. However, this research has shown that this assistance does not necessarily have to be external, but may indeed exist within the existing social structure of schools; an underutilized resource simply waiting to be tapped. In closing, one would be wise to reflect on the sage advice of E. F. Schumacher (1973), who noted: "…it is somewhat foolhardy to put great power into the hands of people without making sure that they have a reasonable idea of what to do with it" (p. 86).

References Cited

American Psychological Association. (2001). *Publication manual of the American Psychological Association (5th ed.).* Washington, D.C.: American Psychological Association.

Atkins, N. E. & Vasu, E. S., (1998). The Teaching with Technology Instrument: Effectively measuring where teachers are and planning for staff development. *Learning and Leading with Technology 25*(8), 35-39.

Bijker, W. E. (2001). Understanding technological culture through a constructivist view of science, technology and society. In S. H. Cutcliffe & C. Mitcham (Eds.), *Visions of STS: counterpoints in science, technology, and society studies.* Albany: State University of New York Press.

Buckingham, A., & Saunders, P. (2004). *The survey methods workbook: From design to analysis.* Cambridge: Polity Press.

Bush, G.W. (2001). *No child left behind*. Washington, D.C.: U.S. Department of Education. Retrieved November 11, 2006 from: https://www.whitehouse.gov/news/reports/no-child-left-behind.pdf.

Cuban, L. (1986). *Teachers and machines: The classroom use of technology since 1920.* New York: Teachers College Press.

Cuban, L., Kirkpatrick, H, & Peck, C. (2001). High access and low use of technologies in high school classrooms: Explaining an apparent paradox. *American Educational Research Journal, 38*(4), 813-834.

Cutcliffe, S. H. (2000). *Ideas, machines and values: An introduction to science, technology and society studies.* Lanham, MD: Rowman & Littlefield Publishers, Inc.

DuFour, R., & Eaker, R. (1998) Professional learning communities at work: Best practices for enhancing student achievement. Bloomington, Indiana: National Education Service.

Eastern Michigan University Dissertation Manual. (2006, Fall). Ypsilanti, MI: Eastern Michigan University Graduate School. Retrieved May 28, 2007 from http://www.gradschool.emich.edu/downloads/downloads_subdir/thesisdissert/dissertation/Diss_MANUAL.pdf.

Eastern Michigan University Request for Human Subjects Approval. (2006, September). Ypsilanti, MI: Division of Academic Affairs. Retrieved May 28, 2007 from: http://ord.emich.edu/downloads;downloads_subdir/humansubjects/emu_forms/app_form_word6.doc.

Finley, L. & Hartman, D. (2004). Institutional change and resistance: Teacher preparatory faculty and technology integration. *Journal of Technology and Teacher Education, 12*(3), 319-337.

Fraenkel, J. R., & Wallen, N. E. (2003). *How to design and evaluate research in education (5th ed.).* Boston: McGraw Hill.

Frank, K. A., Zhao, Y., & Borman, K. (2004). Social capital and the diffusion of innovations within organizations: The case of computer technology in schools. *Sociology of Education, 7*(2), 148-171.

Gray, K. C., (2001). Teachers' perceptions of innovation adoption. *Action in Teacher Education, 23*(2), 30-35.

Grootaert, C., Narayan, D., Nyhan-Jones, V., and Woolcock, M. (2004). *Measuring social capital: An integrated questionnaire.* Washington, D. C.: The World Bank.

Holland, P. E. (2001). Professional Development in Technology: Catalyst for school reform. *Journal of Technology and Teacher Educations, 9*(2), 245-267.

Hurlburt, R. T. (2003). *Comprehending behavioral statistics [3rd ed.].* United States: Wadsworth.

Isaac S. and Michael, W. B. (1995) *Handbook in research and evaluation [3rd ed].* San Diego, California: Educational and Industrial Testing Services.

Johnson, Frank (2006). *Current expenditures for public elementary and secondary education: School year 2003-04* (NCES 2006-352). U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved November 22, 2006 from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2006352.

Kleinman, D. L. (2000a). Democratization of science and technology. In D. L. Kleinman (Ed.), *Science, technology & democracy.* Albany: State University of New York Press.

Kleinman, D. L., (Ed.) (2000b), *Science, technology & democracy.* Albany: State University of New York Press.

Kollie, E. (2005). Tools of the trade: Investing in all kinds of technology makes sense for many reasons, not the least of which include improved education, productivity and efficiency for financial savings. *School Planning and Management 44*(8), 23-25.

Lancaster, P. E., & Lancaster, S. J. C. (2002). Integration, access, & preparation: A school of education's efforts to enhance a state's technology program. *Journal of Special Education Technology(17)*(4) p. 45-8.

Loveless, T. (1996). Why aren't computers used more in *schools? Educational Policy, 10*(4), 448-467.

McRobie, G. (1981). *Small is possible.* New York: Harper & Row, Publishers, Inc.

Myers, J. L. & Well, D. A. (2003). *Research design and statistical analysis [2nd ed.].* Mahwah, New Jersey: Lawrence Erlbaum Associates.

National Commission on Excellence in Education (1983). *A nation at risk: The imperative for educational reform.* Retrieved October 1, 2005 from the United States Department of Education Web site: http://www.ed.gov/pubs/NatAtRisk/index.html.

Nutt, P. & Backoff, R. (1992). *Strategic management of public and third sector organizations.* San Francisco: Jossey-Bass Publishers.

Pearson, G. & Young, T. (Eds.). (2002). *Technically speaking: Why all Americans need to know more about technology*. Washington, DC. National Academy Press.

Pool, R. (1997) *Beyond engineering: How society shapes technology.* New York: Oxford University Press.

Rai, R. K. (2004). Development and implementation of technology plans in Tennessee public school systems. *Dissertation Abstracts International, 66* (01), 77A. (UMI No. 3162012).

Rodgers, E. M. (1995). *Diffusion of innovations [4th ed.].* New York: The Free Press.

Schön, D. A. (1983). The reflective practitioner: How professionals think in action. United States: Basic Books.

Schumacher, E. F. (1973) *Small is beautiful: a study of economics as if people mattered.* London: Blond & Briggs Ltd.

Shibley, I. A. (2001). Technology integrated learning, staff development: It's a total package. *Educational Technology, 41(6),* 61-63.

Smerdon, B., Cronen, S., Lanahan, L., Anderson, J., Iannotti, N., & Angeles, J. (2000). *Teacher's tools for the 21st century: A report on teacher's use of technology (Statistical Analysis Report).* (Report No. NCES-2000-102). Washington DC: National Center for Education Statistics. (ERIC Document Reproduction Service No. ED444599).

Snyder, T. D., Tan, A. G., & Hoffman, C. M. (2005). *The digest of education statistics, 2005.* (Report No. NCES-2006-030). Washington, DC: National Center for Educational Statistics. (ERIC Document Reproduction Service No. ED492945).

Towle, A. (1989). *Modern biology.* New York: Holt, Rinehart and Winston.

United States Congress. (2001). *No child left behind act of 2001*. Public Law 107-110, 107th Congress. Washington, DC: Government Printing Office.

United States Congress, Office of Technology Assessment. (1995). *Teachers and technology: Making the connection*. (Report No. OTA-EMR-616). Washington DC: U.S. Government Printing Office. (ERIC Document Reproduction Service No. ED386155).

Van Duijn, M. A. J., & Vermunt, J. K. (2006). What is special about social network analysis? *Methodology 2(6),* 2-6.

Wells, J., & Lewis, L. (2006). *Internet Access in U.S. Public Schools and Classrooms: 1994–2005* (NCES 2007-020). U.S. Department of Education. Washington, DC: National Center for Education Statistics.

Yager, R. E. (2002). Science-technology-society and education: A focus on learning and how persons know. In S. H. Cutcliffe & C. Mitcham (Eds.), *Visions of STS: counterpoints in science, technology, and society studies.* Albany: State University of New York Press

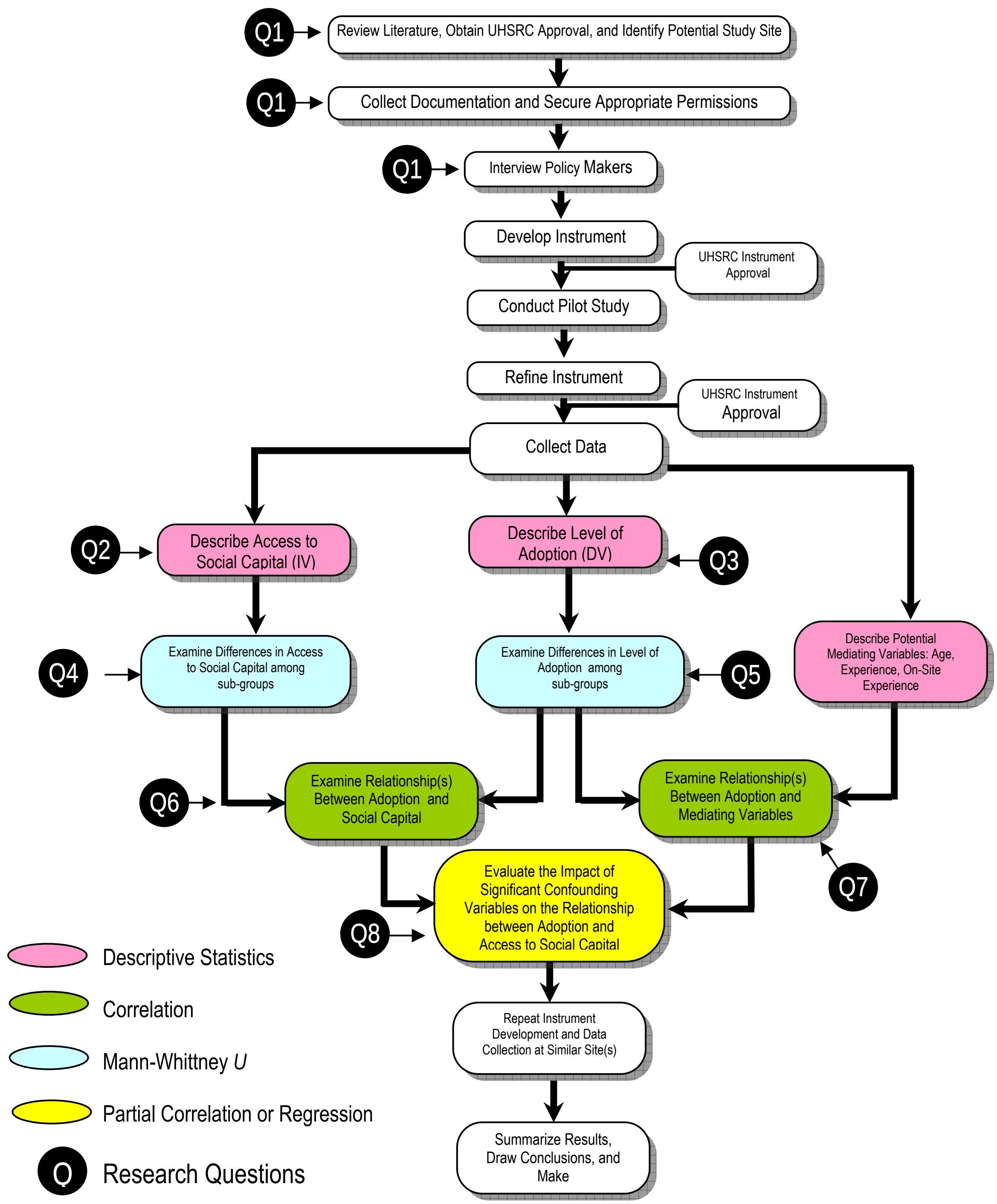
Zhao, Y., & Cziko, G. A. (2001) Teacher adoption of technology: A perceptual control theory perspective. *Journal of Technology and Teacher Education, 9*(1), 5-30.

Zhao, Y. & Frank, K. A. (2003). Factors affecting technology uses in schools: An ecological perspective. *American Educational Research Journal, 40*(4), 807-840.

Zhao, Y., Pugh, K., Sheldon, S., & Byers, J. (2002). Conditions for classroom teacher innovations. *Teachers College Record 104*(3), 842-515.

Appendices

Appendix A: Research Procedure Schematic



Appendix B: Details of Innovative Technology Identification Meetings

The following script/outline was used to conduct each meeting:

1. Welcome attendees to meeting. Pass out informed consent agreements. Record persons in attendance, as well as their assignment / capacity within the study setting.
2. Introduce researcher and give brief overview of research project.
3. Give participants an opportunity to ask any questions. Collect signed informed consent agreements.
4. Define “innovative technology” for participants. Prompt: “For purposes of the research project, an innovative technology can be a piece of equipment, program, process or other resource available to all teachers. It must be new enough that not all teachers have fully adopted it as of Fall semester 2007.”
5. Solicit a list of innovative technologies present in the study site. Prompt: “What innovative technologies are present in your building?”
6. Record all responses in research notebook. Researcher may not be familiar with all technologies, so further explanation could be requested. Typical prompts: “What is that exactly?”, “How would a teacher use that?”, “Is that similar to...?”
7. Encourage more ideas. Prompt: “Are there any other innovative technologies you can think of?”
8. As list grows, continue to read list to participants and have them discuss whether all of the technologies still belong on the list. Typical prompt: “Do you still think that XXXXX is an innovative technology?” Remove any technologies that participants agree does not belong.

9. For remaining items, ask if two or more could be combined under one title. Prompt: “Do any of these technologies depend on one another, or could a single technology cover both?”
10. Remind participants that the study seeks to limit the innovative technologies under observation to between two and four technologies. Prompt: “Remember, the study will only examine two to four of these technologies.”
11. Have participants begin to rank-order their selections by asking them to identify the most innovative or important innovative technology present in the study setting. Prompt: “Which of the technologies on the list do you think is the most innovative or important for the study to examine?”
12. Discuss the selection with all participants until an agreement is made to place that technology on the “final” list.
13. Repeat steps 10-12 until a rank ordered list is created, and all participants agree with the ranking.
14. Ask participants if each of the top selections should be included. Prompt: “Do you think this technology should be included in the study?”
15. If final list is four or less, proceed to next step. Otherwise repeat step 14.
16. Thank participants for their time. Give them contact information if they have further comments or questions.

Note: All technologies, lists and notes were recorded in researcher’s research notebook.

Appendix C: Expert Panel Used for Validity and Reliability Analysis

Name	*Affiliation*	*Qualification*
Dr. John C. Dugger, PhD	Eastern Michigan University	College of Technology, Dissertation Chair
Dr. Sema Kalaian, PhD	Eastern Michigan University	College of Technology, Dissertation Committee Member, Statistics and Research Methods Professor
Dr. Shereen Arraf, PhD	Dearborn Public Schools	Director of Assessment, PhD in Statistics
Dr. John A. Bayerl, PhD	Northern Michigan University	Professor of Guidance and Counseling
Dr. Sean Goffnett, PhD	Central Michigan University	PhD from EMU College of Technology
Mr. Glenn Melynko	Dearborn Public Schools	Middle School Principal, Doctoral Student, EMU College of Education
Mr. Brian Hoxie	Eastern Michigan University	University Administrator, Doctoral Student, EMU College of Technology
Mr. Russell Rhoton	Eastern Michigan University	Lecturer and Doctoral Student, EMU College of Technology

Appendix D: Sample Survey Instrument

Instructions:
- You may complete the following questionnaire in either pen or pencil. The researcher has extra pencils if you need one.
- Please write neatly and legibly, and answer each question as completely as possible.
- When asked to fill in a number, please use a *single number* (example "8") not a *range of numbers* (example 10-12).
- Please complete the questionnaire individually, without consulting your colleagues.
- If you have any questions or do not understand a question, please raise your hand and ask the researcher for clarification.
- When finished, please raise your hand and your completed questionnaire will be collected.

Section 1: Demographic Information

1) Please print your *name* legibly: ______________________ ____________________
(First) (Last)

2) Please check your *gender*: [ ] Male [ ] Female

3) Please write your *current age*: [ ]
(years)

4) Please write the number of years you had been *teaching* prior to the beginning of the Fall 2007 semester (September 4, 2007). Round up to the nearest whole year. If this is your first year teaching, write "0":

[ ] (years) (reminder: write only a single, whole number)

5) Please write the number of years you had been *assigned to this building* prior to the beginning of the Fall 2007 semester (September 4, 2007). Round up to the nearest whole year. If this is your first year teaching in this building, write "0":

[ ] (years) (reminder: write only a single, whole number)

6) Please indicate your *teaching assignment* during the Fall 2007 semester (September 4, 2007 to
January 25, 2008):

_____ Number of extended core (elective) hours

_____ Number of core (academic) hours

_____ Other hours. Explain:________________________________

Section 2: Personal Innovative Technology Assessment

7) Three innovative technologies have been identified in your building: Promethean Boards, the Dukane VHS/DVD system, and Laptop Carts. Under each of the technologies listed in the table below, please place a single check mark (☑) next to the description that best describes your use of that technology in your daily teaching practice during the Fall 2007 Semester (September 4, 2007 to January 25, 2008). You will have a total of three (3) check marks, each in its own column when you're done.

	Promethean Boards	Dukane VHS / DVD System	Laptop Carts
"I was using this technology before anyone else was aware of it"			
"I was among the first to use this technology when it became available"			
"Less than half of the staff was using this technology when I started using it"			
"More than half of the staff was using this technology when I started using it"			
"I have not yet begun to use this technology"			

Instructions for Questions #8-11: Take a moment to reflect on how you and your colleagues have helped, trained, and supported each other as you've learned to use these three technologies during the Fall 2007 semester (September 4, 2007 to January 25, 2008). For each question, please place a single check mark (☑) next to the description that best describes your reaction to the question. You will have a total of three (3) check marks, each in its own column when you're done with each question.

8) *During the Fall 2007 Semester (September 4, 2007 to January 25, 2008) my teacher colleagues where an important source of knowledge, skills, training and support when learning to use innovative technologies (Promethean Boards, Dukane VHS/DVD System, Laptop Carts)in my daily teaching practice."*

	Promethean Board	Dukane VHS/DVD System	Laptop Carts
Strongly Agree			
Agree			
Neither Agree nor Disagree			
Disagree			
Strongly Disagree			

9) *"The knowledge, skills, training and support I receive from my colleagues helped me incorporate innovative technologies (Promethean Boards, Dukane VHS/DVD System, Laptop Carts) into my daily teaching practice."*

	Promethean Board	Dukane VHS/DVD System	Laptop Carts
Strongly Agree			
Agree			
Neither Agree nor Disagree			
Disagree			
Strongly Disagree			

10) *"The assistance I gave to others teachers was an important source of the knowledge, skills, training and support they needed when learning to use innovative technologies (Promethean Boards, Dukane VHS/DVD System, Laptop Carts) in their daily teaching practice."*

	Promethean Board	Dukane VHS/DVD System	Laptop Carts
Strongly Agree			
Agree			
Neither Agree nor Disagree			
Disagree			
Strongly Disagree			

11) *"The help I gave to my colleagues allowed them to successfully incorporate innovative technologies (Promethean Boards, Dukane VHS/DVD System, Laptop Carts) into their daily teaching practice."*

	Promethean Board	Dukane VHS/DVD System	Laptop Carts
Strongly Agree			
Agree			
Neither Agree nor Disagree			
Disagree			
Strongly Disagree			

Section3: Use of Innovations

These questions ask you to indicate how often you used innovative technologies (*Promethean Boards, Dukane VHS/DVD System, Laptop Carts*) during the Fall semester (September 4, 2007 to January 25, 2008).

12) On how many *occasions* did you use the <u>*Promethean Board*</u>in your classroom during the Fall '07 Semester (September 4, 2007 to January 25, 2008?

[ ] (write a single, whole number)

(occasions)

12a) Please indicate which of the following you used the Promethean

Board for:

[ ] As a data projection system
[ ] Video streaming.
[ ] Assessment using the acu-vote system.
[ ] Presenting curricular materials
[ ] Small group instruction
[ ] Other: Please list:

____

____

13) On how many *occasions* did you use a <u>*Dukane VHS/DVD System*</u> in your classroom during the Fall '07 Semester (September 4, 2007 to January 25, 2008?

[ ] (write a single, whole number)

(occasions)

14) On how many *occasions* did you sign out or use a <u>*Laptop Cart*</u> in your classroom during the Fall '07 Semester (September 4, 2007 to January 25, 2008)?

[ ] (write a single, whole number)

(occasions)

14a) Please indicate which of the following you used the Laptop Cart for:

[ ] Internet research
[ ] Small group instruction
[ ] iBlog
[ ] iLearn
[ ] Online text or supplementary materials provided by book publisher.
[ ] Subscription services (Atomic Learning, Study Island)
[ ] Other: Please list:

____

____

____

Section 4: Getting Help

15) Reflect on the teachers who helped you learn to use the Promethean Board during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you received such help from each person. Last, for each person, please check the box that best describes how helpful their help, training and support was as you learned to use the Document Camera during Fall Semester 2007 (September 4, 2007 to January 25, 2008).

Name of Person helping you use the Promethean Board (Please Print) First	Last	**Number of occasions on which they provided help to you.** (Single, whole number)	**How helpful was that support?** 5 = Very Helpful 4 = Somewhat Helpful 3 = Undecided 2 = Somewhat Unhelpful 1 = Not helpful at all

16) Reflect on the teachers who helped you learn to use the Dukane VHS/DVD System during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you received such help from each person. Last, for each person, please check the box that best describes how helpful their help, training and support was as you learned to use the Data Projector during Fall Semester 2007 (September 4, 2007 to January 25, 2008).

Name of Person helping you use the Dukane VHS/DVD System (Please Print) First	Last	**Number of occasions on which they provided help to you.** (Single, whole number)	**How helpful was that support?** 5 = Very Helpful 4 = Somewhat Helpful 3 = Undecided 2 = Somewhat Unhelpful 1 = Not helpful at all

17) Reflect on the teachers who helped you learn to use the Laptop Carts during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you received such help from each person. Last, for each person, please check the box that best describes how helpful their help, training and support was as you learned to use Digital or Video Camera during Fall Semester 2007 (September 4, 2007 to January 25, 2008).

Name of Person helping you use the Laptop Carts (Please Print) First	Last	**Number of occasions on which they provided help to you.** (Single, whole number)	**How helpful was that support?** 5 = Very Helpful 4 = Somewhat Helpful 3 = Undecided 2 = Somewhat Unhelpful 1 = Not helpful at all

Section 5: Giving Help

18) Reflect on the teachers who *you* helped learn to use the Promethean Board during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you provided such help to that person.

Name of Person you Assisted using the Promethean Board during the Fall '07 Semester: *(Please Print)* First	Last	**Number of occasions you provided that assistance** (Single, whole number)

19) Reflect on the teachers who *you* helped learn to use the Dukane VHS/DVD Systgem during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you provided such help to that person.

Name of Person you Assisted using the Dukane VHS/DVD System during the Fall '07 Semester: *(Please Print)* First	Last	**Number of occasions you provided that assistance** (Single, whole number)

20) Reflect on the teachers who *you* helped learn to use a Laptop Carts during Fall Semester 2007 (September 4, 2007 to January 25, 2008). Please print the name of each person in the table below. Also write the number of occasions you provided such help to that person.

Name of Person you Assisted using the Laptop Carts during the Fall '07 Semester: *(Please Print)* First	Last	**Number of occasions you provided that assistance** (Single, whole number)

That's it! You're done! Raise your hand and the researcher will collect the questionnaire.
Thank you for your participation.

Appendix E: Protection and Use of Human Subjects in Research Certification

EASTERN MICHIGAN
UNIVERSITY™

Certificate of Completion

Presented to

John Bayerl

acknowledging completion on 09/24/2005
of module one of the Eastern Michigan University
Responsible Conduct in Research training course:

**Protection and Use of
Human Subjects in Research**

Certificate number:
HS09242005510

Robert Holkeboer, Associate Vice President
Graduate Studies and Research

Appendix F: Eastern Michigan University Request for Human Subjects Approval

CHECK ONE

___ FACULTY/STAFF _X__DOCTORAL ___ MASTER'S ___UG Student

PROJECT TYPE – STUDENTS

X_ Dissertation ___ Master's Thesis ___ GR Project ___ Honor's Thesis

___ UG Project

FACULTY/STAFF/DOCTORAL researchers should submit this completed form and the proposal with all required elements as email attachments to human.subjects@emich.edu. Also, send one hard copy of signed original approval form with proposal and all required elements to: Human Subjects Review Committee, Starkweather Hall, Eastern Michigan University, Ypsilanti, MI 48197 (734.487.0042).

Date Submitted: December 11, 2007

Title of Project: The Diffusion of Innovative Technologies Among Teachers: Examining the relationship between access to social capital and Technology Adoption in Schools.

Principal Investigator: John P. Bayerl

Department: College of Technology, Doctoral Program Phone (248) 543-6287

Email: Bayerl@comcast.net –or- bayerlj@dearborn.k12.mi.us Fax: N/A

Co-PI/Project Director: N/A

If a **student project**, list faculty sponsor: Dr. John C. Dugger, PhD.

***Signature* of faculty sponsor:** X ________________________________

Student number: E0031106
Program and status/year: College of Technology, Doctoral Program
Mailing address: 1561 Moorhouse Street, Ferndale, Michigan 48220

If an **external grant** is being sought for this project, state the funding source and submission deadline: N/A

Is this application _X_ New _____Modification of previously approved study

If Modification:

a. Date of last approval by this Committee N/A

b. Principal Investigator of previously approved protocol N/A
c. Describe any modifications to the previously approved protocol: N/A
d. Were any Human Subjects problems encountered in previous research? No ___ Yes ___
If yes, how were they addressed? N/A

I. If you are requesting an exemption from HSRC review, explain the statutory basis for the requested exemption (see attached list of exempt project types):

N/A

II. Numbers, Types and Recruitment of Subjects

A. Numbers and characteristics of subjects (e.g., age ranges, sex, ethnic background, health status, disabilities, etc.):

(See Proposal pp. 45-48). The subjects of this study will be two or three groups of approximately 30-50 adult, middle school teachers drawn from a single school district (approximately 90-150 total participants). Additionally, the researcher will interview principals, assistant principals, lead teachers and technicians from each

B. Special Classes. Explain the rationale for the use of special classes or subjects such as pregnant women, children, prisoners, mentally impaired, institutionalized, or others who are likely to be particularly vulnerable.

None.

C. How are the individual participants to be recruited for this research? Is it clear to the subjects that participation is voluntary and that they may withdraw at any time without negative consequences?

(See Proposal pp 48-51). The researcher will collect data from teachers at a single, existing staff meeting. Participants will be given a description of the research as well as informed consent documentations. The voluntary nature of participation will be specifically explained to the participants, prior to participation, both verbally and in written documentation.

III. Informed Consent

A. To what extent and how are the subjects to be informed of research procedures before their participation?

Voluntary participation in the research involves only filling out a survey questionnaire. All participants will be given verbal and written instructions before participating in the research (should they choose to do so). A question and answer session will be included for purposes of clarification and the addressing of concerns.

B. Attach a copy of the written "Informed Consent” form or a written statement of the oral consent. (See attached checklist for essential elements of informed consent).

Checklist attached. See also, Proposal Appendix D.

IV. Risks Involved in the Research

Describe potential risks involved in project/research participation. What procedures will be in place to minimize any risks to subjects?

(See proposal pp 49-51). Due to the nature of research into social networks, participants will be asked to provide potentially identifying information in the process of completing the questionnaire. While this information is necessary to construct variables, personal information will not be reported in the results—only the aggregate. However, it is acknowledged that this might lead to personal or professional criticism or embarrassment, both real or imagined. The researcher will take specific precautions to minimize or eliminate these risks including:

1) All participants will be provided with a copy of this research proposal, as well as two copies of an informed consent letter. A signed copy of the informed consent letter will be returned to the researcher.
2) Only participants and the researcher will be allowed in the room while surveys are being filled out. The researcher will hand collect all surveys and seal them in a large envelope upon completion.
3) Surveys will be stored in a locked file cabinet off-site until they are entered into the statistical software for analysis. After data is coded and checked for accuracy, paper surveys will be destroyed via a paper shredder.
4) After data is coded and variables constructed, actual teacher names will be replaced with pseudonyms assigned using a random number table and a “baby names” book and original documents with identifying information will be destroyed by paper shredder.
5) Actual teacher names will never be used in reporting results, analyzing findings or reporting conclusions. If it is necessary to refer to a specific teacher in order to illustrate a point, the pseudonym will be used along with no other identifying information.
6) Results for individual sub-groups will be reported in the aggregate. Small groups (3 or fewer participants) will be avoided both to preserve anonymity and confidentiality and to increase validity of results.

7) No identifying information will be included with any historical documents included in the analysis. If such information is included, and the resource must be included, that information will be physically redacted (deleted via word processor and replaced with an ellipse (…) or cut from the document with a razor blade prior to scanning).
8) Data files will be stored on password protected computers owned by the researcher. Data transfer between machines will be made via 128-bit encrypted USB flash memory, not via email, ftp, or other non-secure network protocol.
9) After publication of the researcher’s dissertation, all related data files and other data collected will be destroyed.
10) Participants will be free to withdraw from the study at any time, with no explanation or and no negative consequences.
11) Should any other requirement emerge from UHSRC or district review, such requirements will be amended to this proposal before conducting the research.

Does the research involve any of the following procedures?

Deception of the participant?	**No** __X__ Yes ___
Punishment of the participant?	**No** __X__ Yes ___
Use of drugs/medications in any form?	**No** __X__ Yes ___
Electric shock?	**No** __X__ Yes ___
Deliberate production of anxiety or stress?	**No** __X__ Yes ___
Materials commonly regarded as socially unacceptable?	**No** __X__ Yes ___
Use of radioisotopes?	**No** __X__ Yes ___
Use of chemicals?	**No** __X__ Yes ___
Drawing of blood?	**No** __X__ Yes ___
Handling of any other bodily fluid?	**No** __X__ Yes ___
Any other procedure that might be regarded as inducing in the participant any altered state or condition potentially harmful to his/her personal welfare?	**No** __X__ Yes ___
Any other procedure that might be considered to be an invasion of privacy?	**No** __X__ Yes ___
Disclosure of the name of individual participants?	**No** __X__ Yes ___
Any other physically invasive procedure?	**No** __X__ Yes ___

If the answer to any of the above is "Yes,” please explain this procedure in detail and describe procedures for protecting against or minimizing any potential risk.

N/A

V. Confidentiality

A. To what extent is the information confidential and to what extent are provisions made so that subjects are not identified?

(See proposal pp. 49-51). Names of participants and their colleagues will be collected in order to map the complex interactions between participants. Some personal information (age, gender, classroom assignment, classroom language, teaching experience) will also be collected. However, these data will be coded and used in the creation of variables. In this process, the identity of individuals will be eliminated, producing aggregate data used for analysis.

B. What are the procedures for handling and storing data so that confidentiality of the subjects is protected (particular attention should be given to the use of photographs, video and audio recordings)?

(See proposal pp. 49-51. See also: Section IV: Risks Involved in Research Above). Specific procedures are in place to both handle and store data including the use of sealed envelopes, assignment of random identification to individual responses, storage of data in locked cabinets and secure electronic storage as well as the destruction of data once research is completed. For more detail please refer to proposal for details.

C. How will the results of the research be disseminated? Will the subjects be informed of the results? Will confidentiality of subjects or organizations be protected in the dissemination? Explain.

Primary outlet for dissemination of results will be the publication of the researcher's doctoral dissertation—a requirement of the degree program. Results may—upon request—be shared with participants at another staff meeting. It is important to acknowledge that results are expressed in terms of the organization, and not the individual.

VI. Describe any anticipated benefits to subjects from participation in this research.

The purpose of the research is to explore the relationship between social interactions (social capital) and adoption of educational technologies in school. As such, knowledge gained from the study may be used to better understand these issues in the participants workplace, and might lead to improved usage of those technologies.

VII. Submitting Your Protocol – CHECKLIST

__X__ If this is a Doctoral dissertation, Master's or Honor's thesis, please attach your **Committee Approval form**. NOTE: Master's and Honor's thesis that are not beyond minimal risk should be submitted to College committees. Check here if not applicable _____.

__X__ If available, attach a full copy of your research proposal (grant, thesis, dissertation proposal, etc.) Check here if not available _____.

__X__ Regardless of whether or not a full research proposal is available, attach a concise summary (2-5 pages) that includes:

- A brief summary of the background literature stimulating this research
- Rationale for the proposed study, including goals, research questions or hypotheses
- A description of the participants and how they will be recruited
- A detailed description of study methodology

NOTE: You may "cut-and-paste" as needed from your full proposal, if available, and the committee may refer to the full proposal for clarification.

__X__ Consent Agreement(s) -- (Check here if not applicable _____). See attached checklist of required elements to include in these consent documents.
NOTE: Please add the following statement to the final copy of your Informed Consent Agreement: **"This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from _________ to _________ (date). If you have questions about the approval process, please contact Dr. Deb de Laski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-chair of UHSRC, human.subjects@emich.edu)."**

__X__ Copies of all instruments, questionnaires, or tests to be used (if instruments are not fully developed yet, attach drafts, and so indicate).**—Sample draft of instrumentation is included in Appendix E of the proposal.**

_N/A__ If your research constitutes institutional or departmental assessment, your study should have first been approved by the Director of EMU Institutional Assessment; if it has been, on what date __________ . Please attach confirmation of approval. Check here if not applicable _____.

_N/A__ Flyers to be posted on campus (**NOTE**: These must be stamped with Committee Approval prior to posting).

For clarification on human subjects procedures at EMU, please see this webpage: http://www.ord.emich.edu/federal/federal_comp_subdir/humansubjects/human.html

Principal Investigator ____
(Signature)

Date: ______________________________

Checklist of Required Elements of Informed Consent

__**X**__ A statement that the study involves research

__**X**__ Purpose of the research

__**X**__ Duration of subject's participation

__**X**__ Description of the procedures followed

X Means of public dissemination

X Description of foreseeable risks or discomforts to subject

X Description of benefits to subject or to others

N/A Disclosure of appropriate alternative procedures or courses of treatment

X Statement of extent to which confidentiality of records identifying subject is maintained

X Statement of how participant confidentiality is maintained in public dissemination

N/A For research that poses greater than minimal risk, information regarding medical treatments or counseling should personal injury or problems occur

X List of contacts who can answer questions about the research and subject's rights and respond to research-related injury to subject. Include the paragraph above regarding how to contact the UHSRC, in addition to information about how to contact the investigator(s).

X Statement that participation is voluntary

X Statement that refusal to participate will involve no penalty or loss of benefits

X Statement that the subject may discontinue participation at any time

X Statements of significant new findings developed during the course of research that may relate to subjects' willingness to continue participation

Rationale for Exclusion of a Required Element: N/A

Appendix G: UHSRC Approval of Initial Proposal

EASTERN MICHIGAN UNIVERSITY
Education First

January 18, 2008

John Bayerl
1561 Moorhouse St
Ferndale, MI 48220

Dear John Bayerl:

The Human Subjects Institutional Review Board (IRB) of Eastern Michigan University has granted approval to your proposal, "The Diffusion of Innovative Technologies Among Teachers: Examining the Relationship Between Access to Social Capital and Technology Adoption in Schools."

After careful review of your completion application, the IRB determined that the rights and welfare of the individual subjects involved in this research are carefully guarded. Additionally, the methods used to obtain informed consent are appropriate, and the individuals participating in your study are not at risk.

You are reminded of your obligation to advise the IRB of any change in the protocol that might alter your research in any manner that differs from that upon which this approval is based. Approval of this project applies for one year from the date of this letter. If your data collection continues beyond the one-year period, you must apply for a renewal.

On behalf of the Human Subjects Committee, I wish you success in conducting your research.

Sincerely,

Deb de Laski-Smith, Ph.D.
Interim Dean
Graduate School
Administrative Co-Chair
University Human Subjects Review Committee

Note: If project continues beyond the length of one year, please submit a continuation request form by 1/18/09.

Reference # 071208

University Human Subjects Review Committee · Eastern Michigan University · 200 Boone Hall
Ypsilanti, Michigan 48197
Phone: 734.487.0042 Fax: 734.487.0050
E-mail: human.subjects@emich.edu
www.ord.emich.edu

Appendix H: UHSRC Approval of Revised Proposal

EASTERN MICHIGAN UNIVERSITY

Education First

February 18, 200

John Bayerl
1561 Moorhouse St
Ferndale, MI 48220

Dear John Bayerl:

The Human Subjects Institutional Review Board (IRB) of Eastern Michigan University has granted approval to your modified proposal, "The Diffusion of Innovative Technologies Among Teachers: Examining the Relationship Between Access to Social Capital and Technology Adoption in Schools."

After careful review of your completed application, the IRB determined that the rights and welfare of the individual subjects involved in this research are carefully guarded. Additionally, the methods used to obtain informed consent are appropriate, and the individuals participating in your study are not at risk.

You are reminded of your obligation to advise the IRB of any change in the protocol that might alter your research in any manner that differs from that upon which this approval is based. Approval of this project applies for one year from the date of this letter. If your data collection continues beyond the one-year period, you must apply for a renewal.

On behalf of the Human Subjects Committee, I wish you success in conducting your research.

Sincerely,

Deb de Laski-Smith, Ph.D.
Interim Dean
Graduate School
Administrative Co-Chair
University Human Subjects Review Committee

Note: If project continues beyond the length of one year, please submit a continuation request form by 2/15/09.

Reference # 080220M

University Human Subjects Review Committee · Eastern Michigan University · 200 Boone Hall
Ypsilanti, Michigan 48197
Phone: 734.487.0042 Fax: 734.487.0050
E-mail: human.subjects@emich.edu
www.ord.emich.edu

Appendix I: Informed Consent Agreement

Project Title: The Diffusion of Innovative Technologies Among Teachers: Examining the Relationship between Access to Social Capital and Technology Adoption in Schools.

Investigator: John P. Bayerl, College of Technology, Eastern Michigan University
Co-Investigator / Advisor: Dr. John C. Dugger, PhD.

Purpose of the Study: The purpose of this research study is to gain a better understanding of the relationships between social interactions of teachers and the level of technology adoption in schools.

Procedure:

- The researcher will explain the study to you, answer any questions you may have, and witness your signature to this consent form.
- You will be asked to complete questionnaires about your use of several key pieces of technology available in your school, as well as your interactions with your colleagues as you learn(ed) how to use those technologies. You will also be asked a few demographic questions for purpose of examining the other variables among sub-groups.
- Upon completing the questionnaires, you will be given a duplicate copy of this informed consent, which includes follow-up contact information, if needed. The approximate total time to complete the questionnaires should be about 10-15 minutes.

Confidentiality:

You will be asked to provide your name and the name of some of your colleagues during this survey. This is necessary to model the flow of information between teachers in your building. Once the structure of this web of interactions is known, the researcher will replace each of the names with a randomly generated alias. Only these aliases will be used in the final results. Results will be stored separately from the consent form, which includes your name. All information will be kept in locked file cabinets of the study investigator.

Expected Risks:

There are no foreseeable risks to you by completing this survey, as all results will be kept completely confidential.

Expected Benefits:

Based on the results of this survey, patterns of usage of selected technologies will be identified along with the effect of social interactions on learning to use those technologies. These findings will be used to provide meaningful professional development aimed at increasing use of educational technologies in your building.

Voluntary Participation:

Participation in this study is voluntary. You may choose not to participate. If you do decide to participate, you can change your mind at any time and withdraw from the study without negative consequences.

Use of Research Results:

Results will be presented in aggregate form only. No names or individually identifying information will be revealed. Results may be presented at research meetings and conferences, in scientific publications, and as part of a doctoral dissertation being conducted by the principal investigator.

Future Questions:

If you have any questions concerning your participation in this study now or in the future, you can contact the principal investigator, John P. Bayerl at (248) 543-6287 or via e-mail: bayerlj@dearborn.k12.mi.us.

This research protocol and informed consent document has been reviewed and approved by the Eastern Michigan University Human Subjects Review Committee for use from January 8, 2008 to January 9, 2009. If you have questions about the approval process, please contact Dr. Deb de Laski-Smith (734.487.0042, Interim Dean of the Graduate School and Administrative Co-Chair of UHSCR, human.subjects@emich.edu.

Consent to Participate:

I have read or had read to me all of the above information about this research study, including the research procedures, possible risks, side effects, and the likelihood of any benefit to me. The content and meaning of this information has been explained and I understand everything that has been presented. All my questions, at this time, have been answered. I hereby consent and do voluntarily offer to follow the study requirements and take part in the study.

PRINT NAME: ____

Signatures:

X____ ____________

Participant (your signature) Date

X____ ____________

Investigator Date

Appendix J: District Permission to Conduct Research

From: Artis, John B
Sent: Thu 12/13/2007 3:31 PM
To: Bayerl, John P
Subject: RE: Permission to conduct Doctoral Research.

John, permission granted. John Artis

From: Bayerl, John P
Sent: Thursday, December 13, 2007 2:55 PM
To: Artis, John B
Cc: Mital, Dawn M
Subject: Permission to conduct Doctoral Research.

Dr. Artis:

Greetings. In addition to teaching GIS at the Michael Berry Career Center, I have been pursuing my PhD in Technology from Eastern Michigan University. My research interest is in the diffusion of technology innovations by teachers (how do new technologies spread through the school). I recently had my research proposal approved by my dissertation committee and have submitted it to the University Human Subjects Research Committee at EMU for approval.

I would like your permission to conduct a survey at 2-3 of our middle schools. The research would include:

1. Meeting with the principal, media specialist and other key technology team members in each building for about 30 minutes to identify some target innovations being used at each site. The purpose of this is to develop a custom instrument to measure the level of usage of those technologies.

2. Collecting data via the survey from the staff at a Monday staff meeting second semester (about 20 minutes time).

My target date to begin is the middle of January. I have some flexibility in the data collection, but the nature of our calendar, and breaks second semester places some limitations on such research.

I have talked informally to a couple of principals who are interested in helping with the research, but am waiting for all the appropriate approvals before formally asking them.

I've attached a summary of the proposal and related documents for you to review. I am always available to discuss this in greater detail if you need more clarification.
Thanks,

John P. Bayerl

Appendix K: Data Collection Cover Letter

Teachers:

Thank you for taking time out of your busy schedule to participate in this research project. I am looking at the adoption of innovative technologies in schools, and the role of teacher interactions in that adoption. This scientific research project has been reviewed and approved by the Eastern Michigan University Human Subjects Review Board, my dissertation committee, and our superintendent, Dr. John Artis.

You will find two copies of an informed consent agreement attached to this letter. Before filling out the questionnaire, you will be required to sign one of these agreements and give it to the researcher. The second copy is for your records and contains contact information about the researcher should you have any questions or concerns at a later date.

Every effort has been made to protect your identity, anonymity and confidentiality in the published results. These results will be in the form of aggregate data, with no person identified individually. Copies of the results will be made available to you if you would be interested in them. Simply contact the researcher and let him know you would like a copy.

Participation in this study is completely voluntary, and you may withdraw from the project at any time. If you have any questions, concerns or comments, please feel free to ask me before consenting to participate.

Thank you again for helping me in this endeavor.

Sincerely,

John Bayerl
PhD Candidate
College of Technology
Eastern Michigan University
bayerlj@dearborn.k12.mi.us

Appendix L: Follow-Up E-Mail to Participants who missed the Data Collection Meeting

From: Bayerl, John P
Sent: Tuesday …
To: …
Subject: Teacher Technology Survey from staff meeting yesterday.

Dear Colleagues,

My name is John Bayerl and I teach at the Michael Berry Career Center. I am also a PhD student at Eastern Michigan University, College of Technology. With the blessing of the University, [the superintendent] and your Principal, …, I am doing my dissertation research on teachers' use of innovative technologies at your Middle School last semester.

I presented a staff survey yesterday to all the teachers at the staff meeting. In order to make my results a little better, I would like to collect responses from as many teachers as possible. I am sending you this email because you are one of the teachers who were not in attendance. I hope that you will consider participating in my study by filling in a brief questionnaire. I am sending them to you through interschool mail. In each package you will find:

1. A white cover letter that is yours to keep.
2. A green informed consent letter that you must sign and return to me should you choose to participate.
3. A yellow survey that needs to be filled out and returned to me should choose to participate.

They went out in inter-school mail today. If you would like to participate, simply fill out the yellow and green sheets and send them back to me through inter-school mail. If you are concerned about the confidentiality of your answers, I can arrange to stop by after school and pick them up personally. I would like them returned by Friday March 28th (or earlier if possible, but I know you're busy at the end of the marking period). Thank you for your consideration.

Sincerely,

John Bayerl

Appendix M: Final Follow-Up E-Mail to Missing Participants

From: Bayerl, John P
Sent: …
To: …

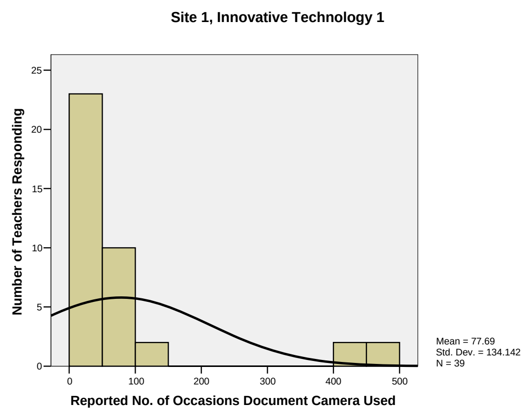
Colleagues:

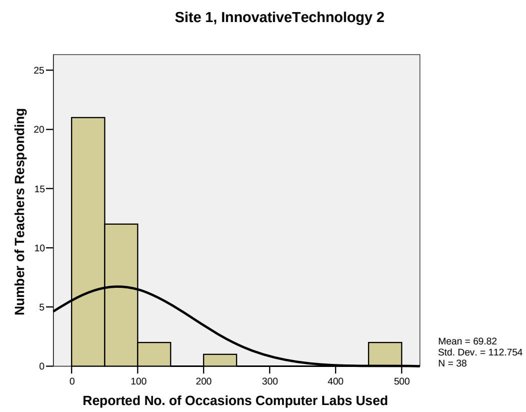
Just a reminder, I am conducting a research study of teachers, technology, and social interaction in your building. I sent you a survey through inter-office mail last week. Just in case you did not receive it, or have misplaced it, I have attached an electronic version to this email. If you could please fill out the informed consent letter (last two pages of the cover letter), and the brief survey and return them to me by this Friday (March 28) it would help me a great deal. Thanks again!

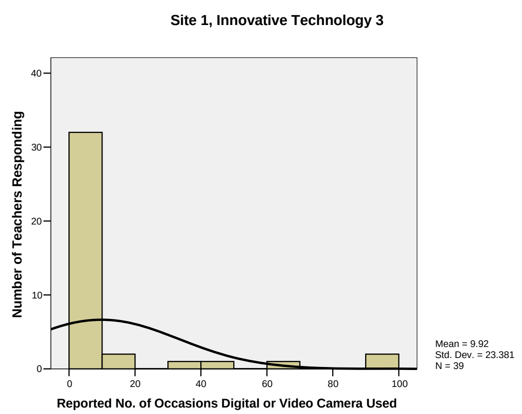
John P. Bayerl

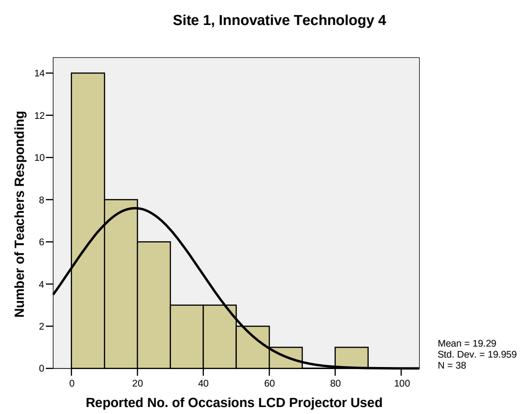
Appendix N: Statistical Charts

This appendix contains the SPSS graph output for various analyses conducted during the study including distribution of adoption data histograms (Figure N-1), distribution of access to social capital data (Figure N-2), scatter plots comparing access to social capital and level of adoption data (Figure N-3) and distribution of potentially confounding variable histograms (Figure N-4).

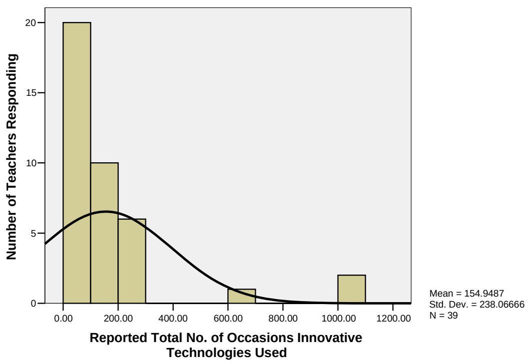




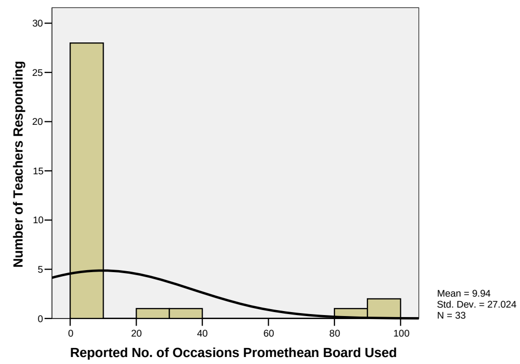




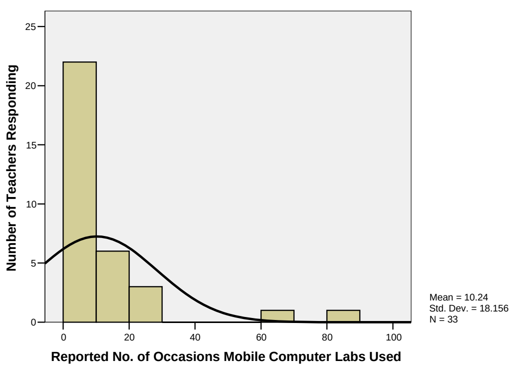
Site 1, Total Level of Innovative Technology Adoption



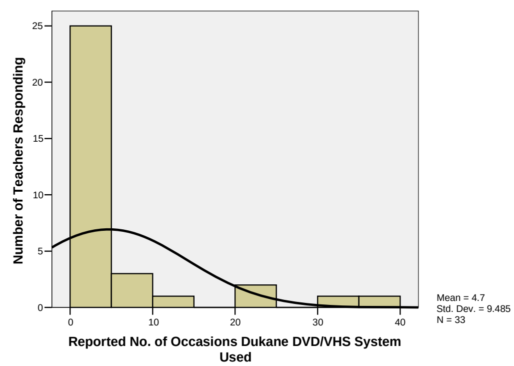
Site 2, Innovative Technology 1



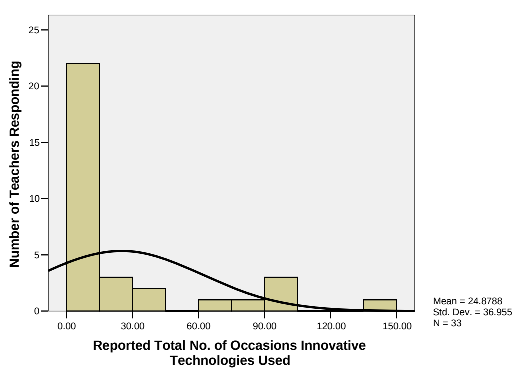
Site 2, Innovative Technology 2



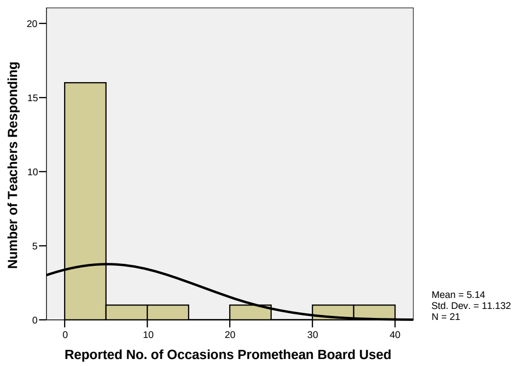
Site 2, Innovative Technology 3



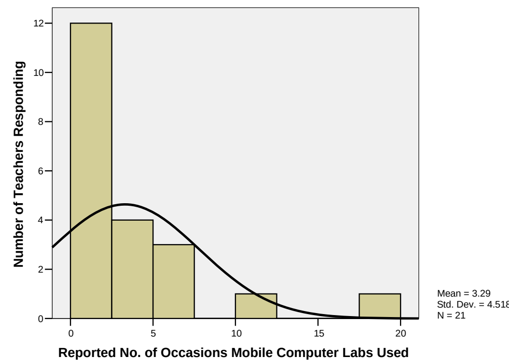
Site 2, Total Level of of Innovative Technology Adoption



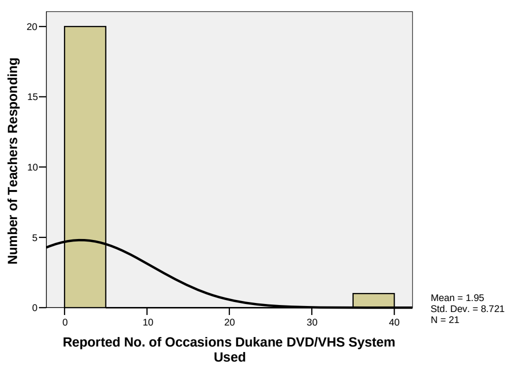
Site 3, Innovative Technology 1



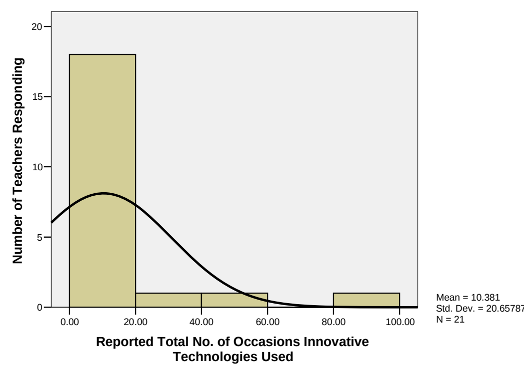
Site 3, Innovative Technology 2



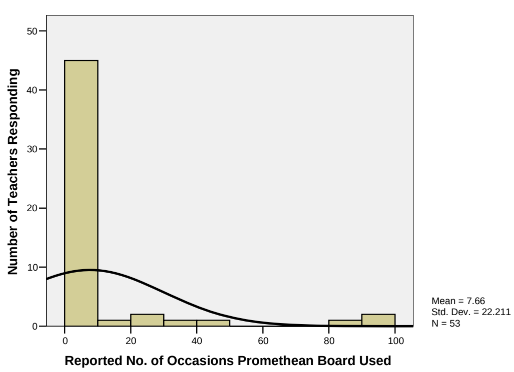
Site 3, Innovative Technology 3



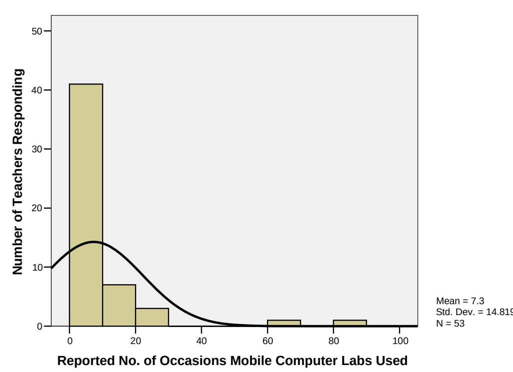
Site 3, Total Level of Innovative Technology Adoption



Site 2 + Site 3 Merged, Innovative Technology 1



Site 2 + Site 3 Merged, Innovative Technology 2



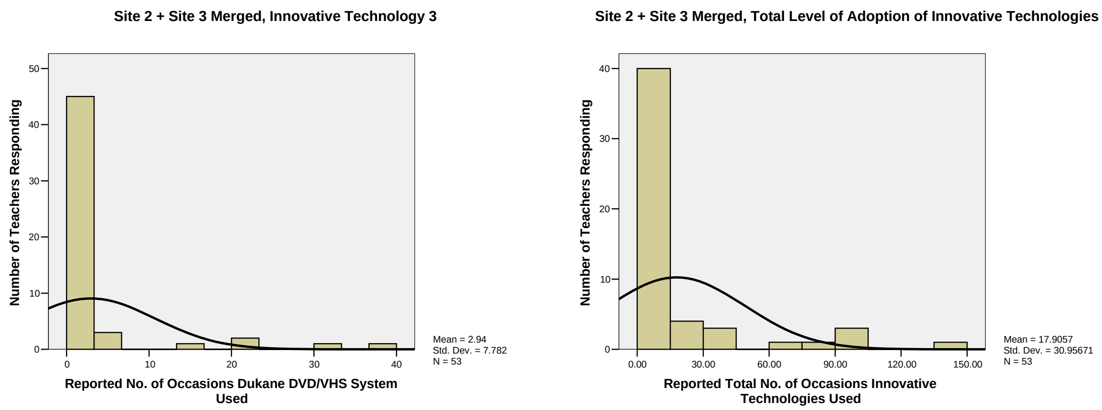
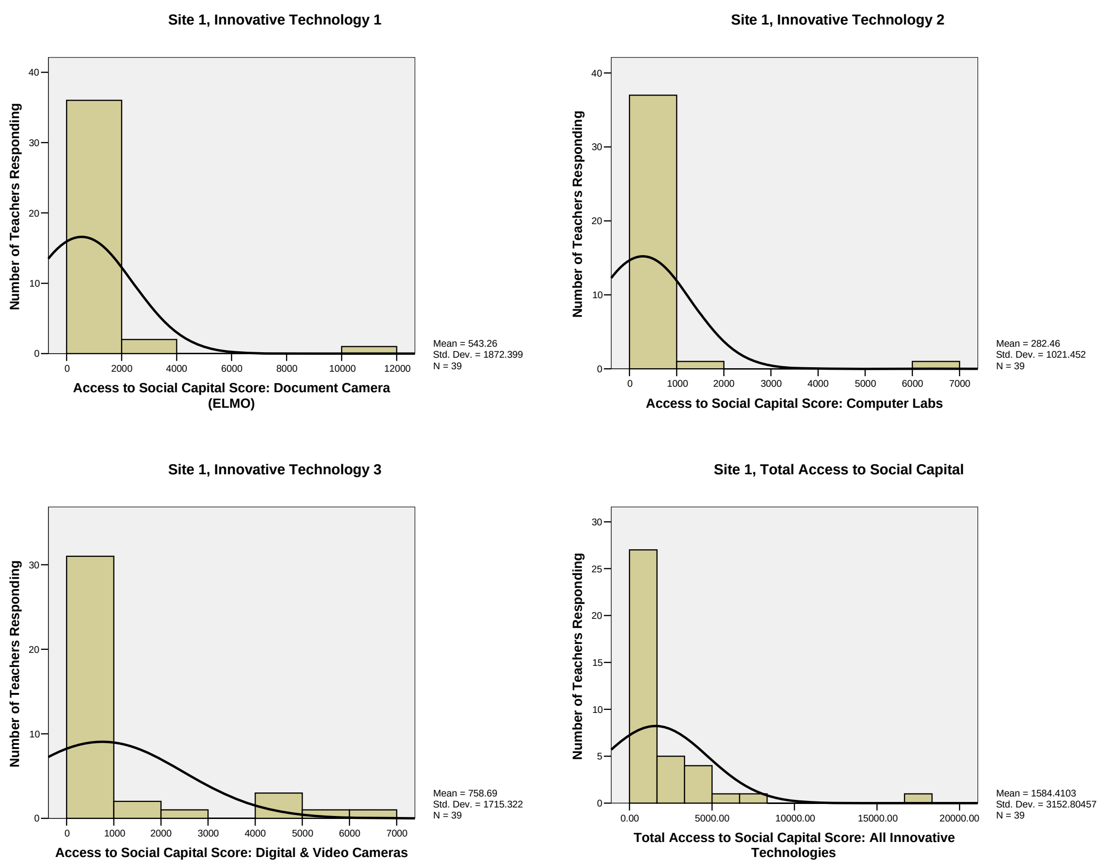
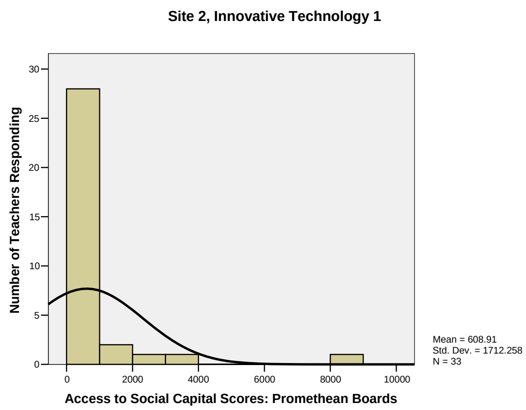
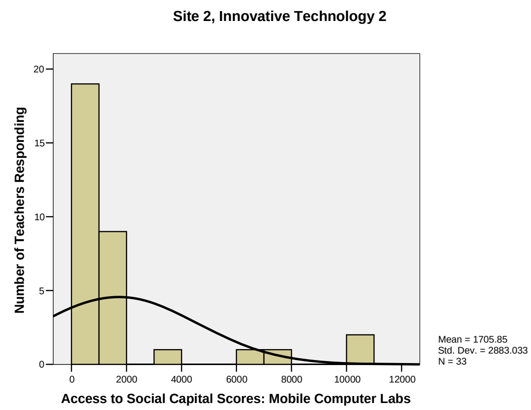
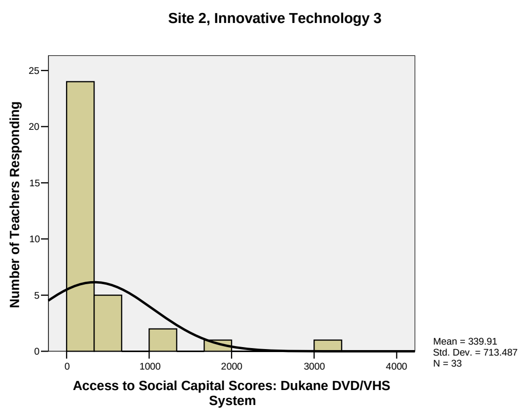


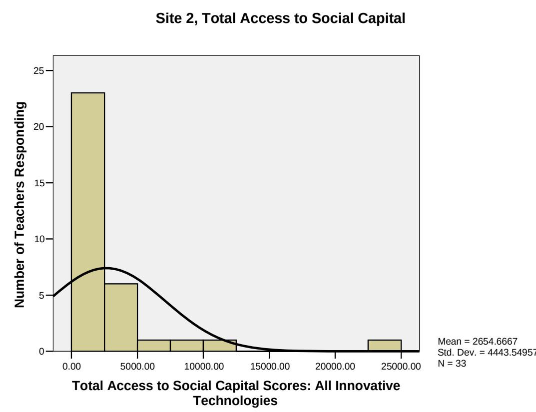
Figure N-1. Distribution of level of adoption histograms

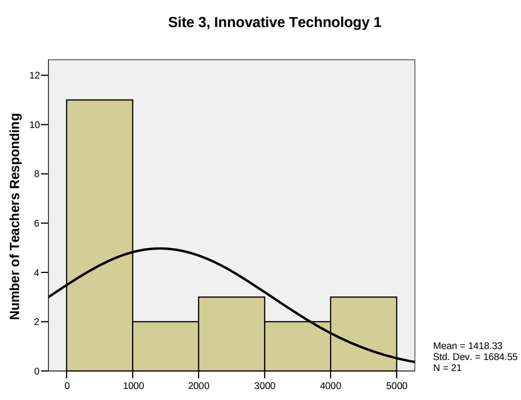


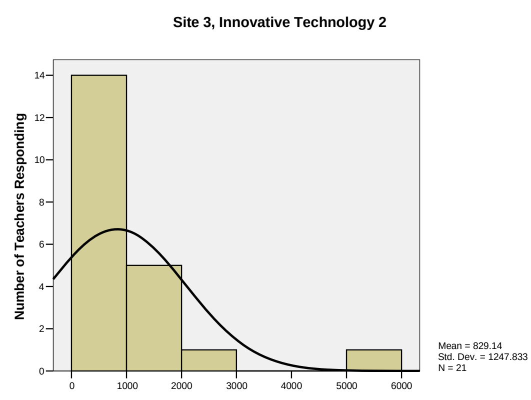

Site 2, Innovative Technology 1
Number of Teachers Responding
Access to Social Capital Scores: Promethean Boards
Mean = 608.91
Std. Dev. = 1712.258
N = 33


Site 2, Innovative Technology 2
Number of Teachers Responding
Access to Social Capital Scores: Mobile Computer Labs
Mean = 1705.85
Std. Dev. = 2883.033
N = 33


Site 2, Innovative Technology 3
Number of Teachers Responding
Access to Social Capital Scores: Dukane DVD/VHS System
Mean = 339.91
Std. Dev. = 713.487
N = 33


Site 2, Total Access to Social Capital
Number of Teachers Responding
Total Access to Social Capital Scores: All Innovative Technologies
Mean = 2654.6667
Std. Dev. = 4443.54957
N = 33


Site 3, Innovative Technology 1
Number of Teachers Responding
Access to Social Capital: Promethean Boards
Mean = 1418.33
Std. Dev. = 1684.55
N = 21


Site 3, Innovative Technology 2
Number of Teachers Responding
Access to Social Capital Scores: Mobile Computer Labs
Mean = 829.14
Std. Dev. = 1247.833
N = 21

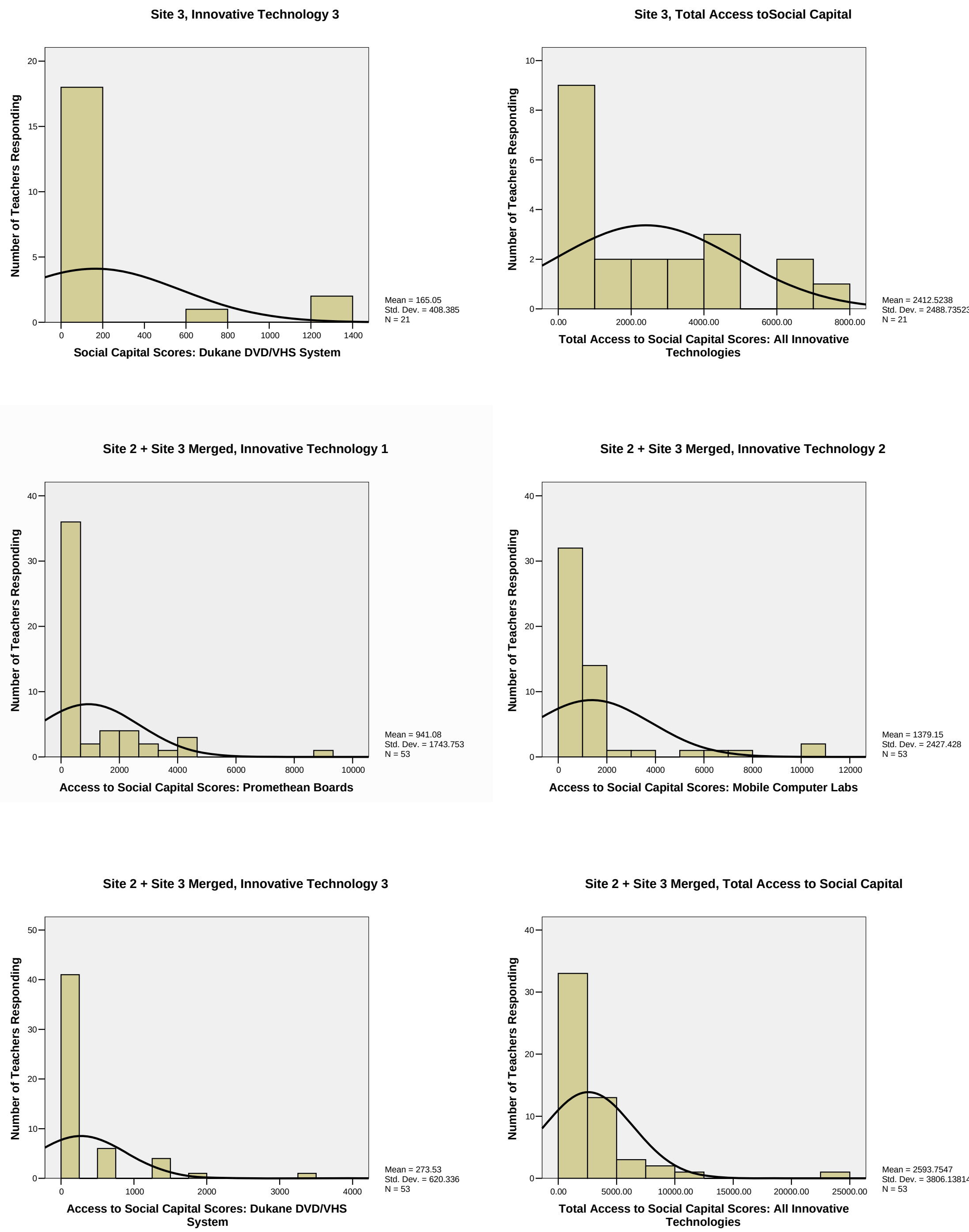
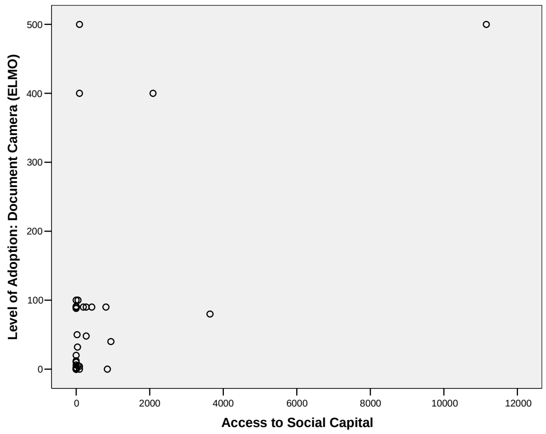
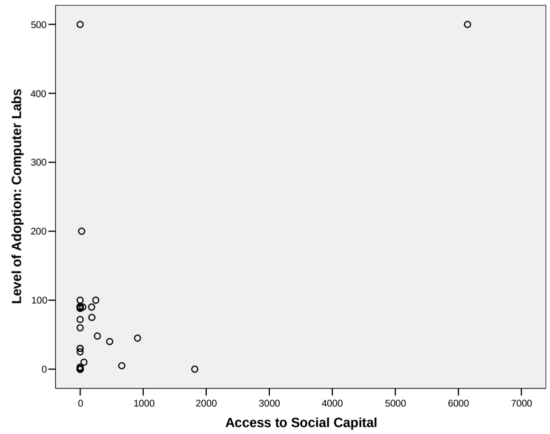
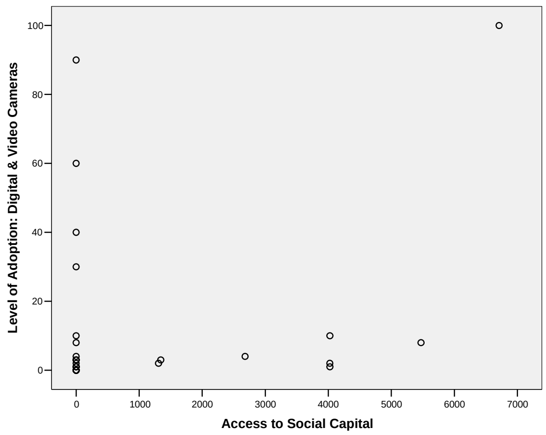


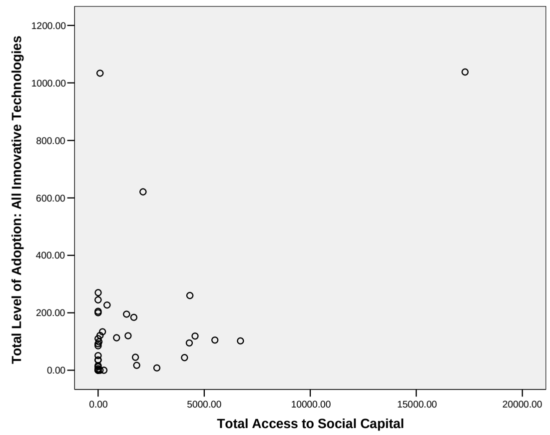
Figure N-2. Distribution of access to social capital histograms

Site 1

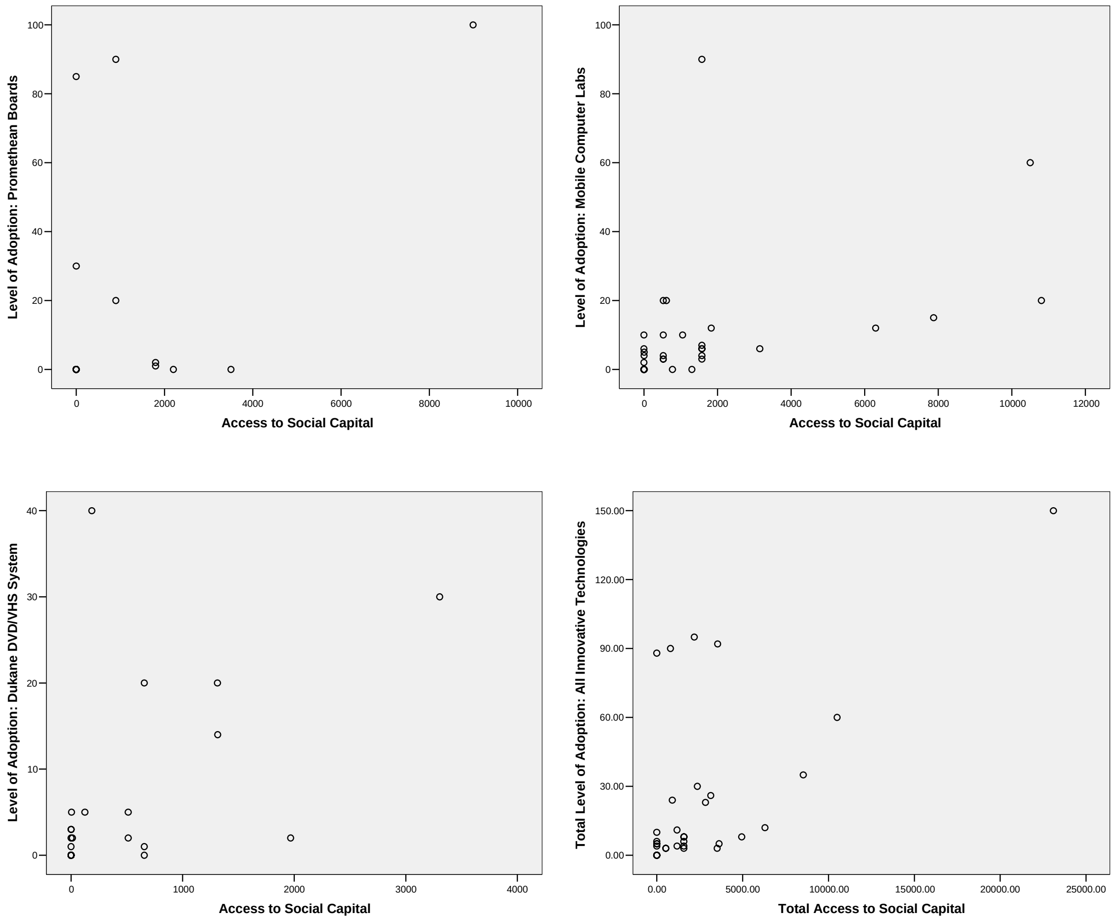

Level of Adoption: Document Camera (ELMO)
0
100
200
300
400
500
0
2000
4000
6000
8000
10000
12000
Access to Social Capital


Level of Adoption: Computer Labs
0
100
200
300
400
500
0
1000
2000
3000
4000
5000
6000
7000
Access to Social Capital

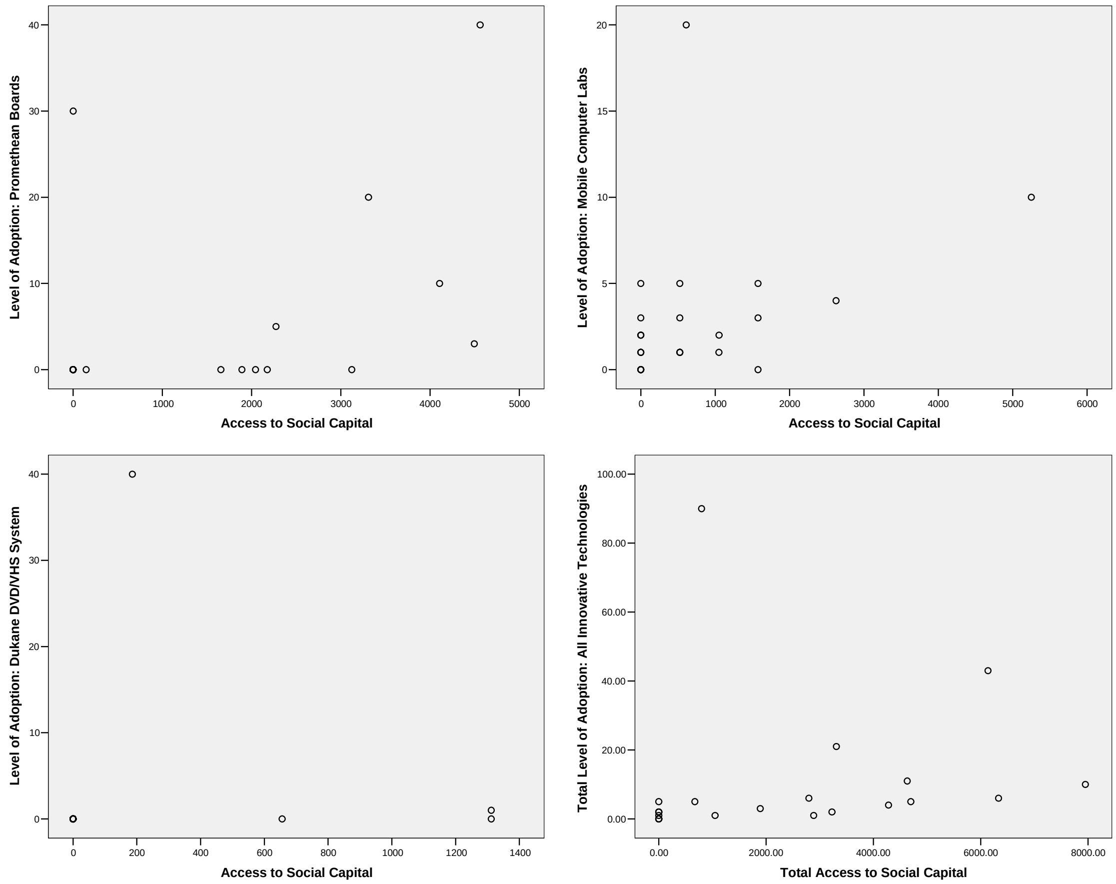

Level of Adoption: Digital & Video Cameras
0
20
40
60
80
100
0
1000
2000
3000
4000
5000
6000
7000
Access to Social Capital


Total Level of Adoption: All Innovative Technologies
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
0.00
5000.00
10000.00
15000.00
20000.00
Total Access to Social Capital

Site 2


Level of Adoption: Promethean Boards
Access to Social Capital
Level of Adoption: Mobile Computer Labs
Access to Social Capital
Level of Adoption: Dukane DVD/VHS System
Access to Social Capital
Total Level of Adoption: All Innovative Technologies
Total Access to Social Capital

Site 3


Level of Adoption: Promethean Boards
0
10
20
30
40
0
1000
2000
3000
4000
5000
Access to Social Capital
Level of Adoption: Mobile Computer Labs
0
5
10
15
20
0
1000
2000
3000
4000
5000
6000
Access to Social Capital
Level of Adoption: Dukane DVD/VHS System
0
10
20
30
40
0
200
400
600
800
1000
1200
1400
Access to Social Capital
Total Level of Adoption: All Innovative Technologies
0.00
20.00
40.00
60.00
80.00
100.00
0.00
2000.00
4000.00
6000.00
8000.00
Total Access to Social Capital

Site 2 + Site 3 Merged

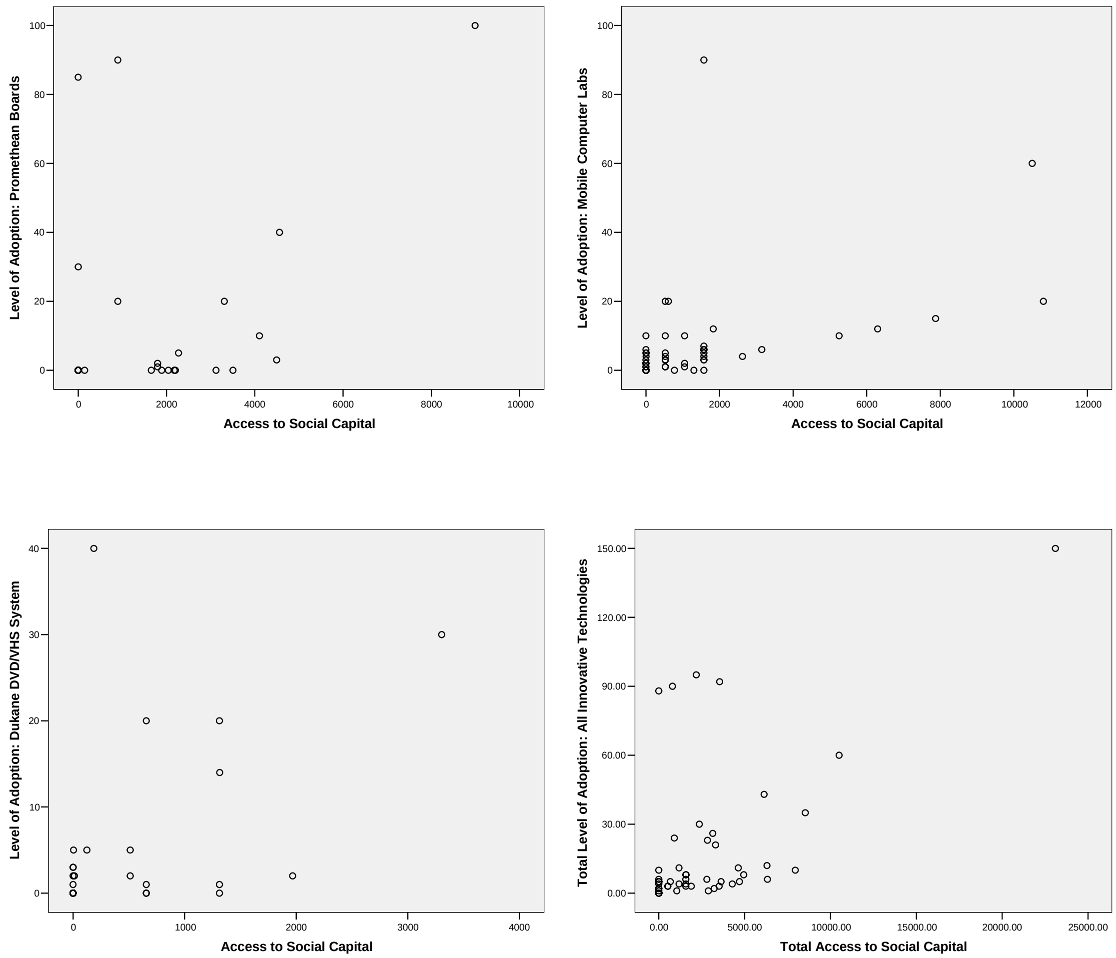
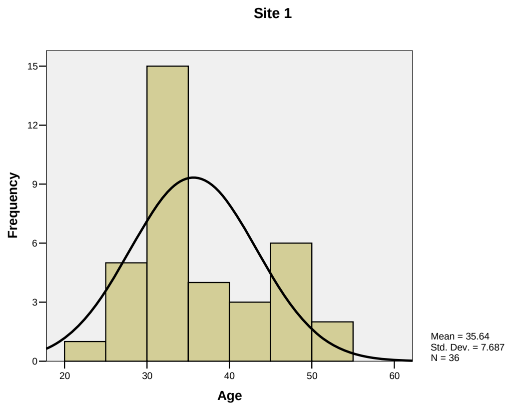
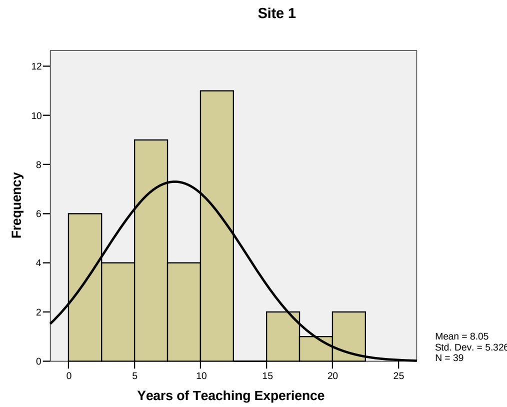
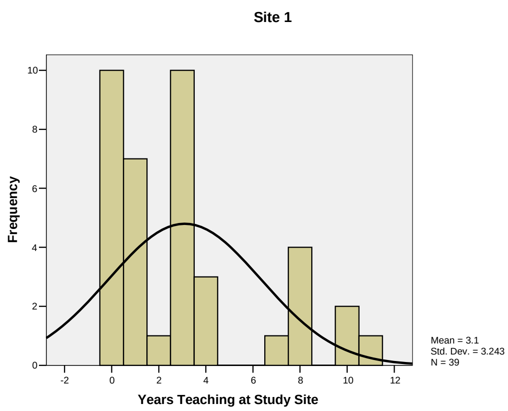
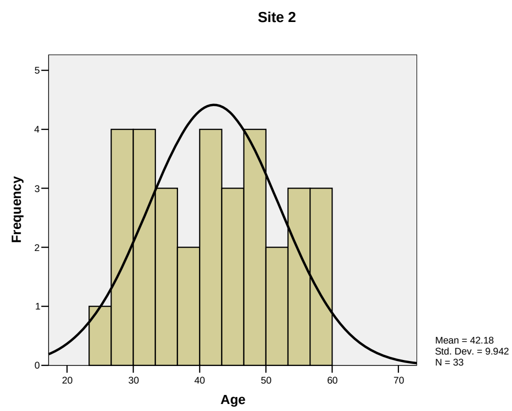


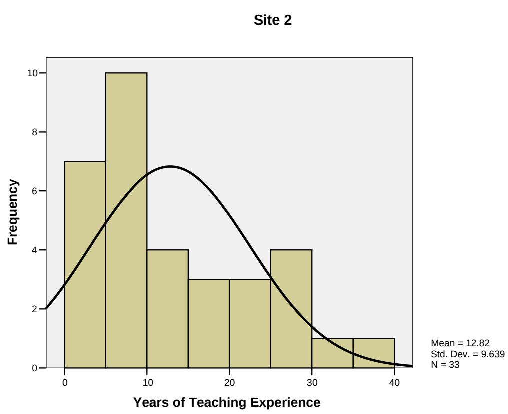
Figure N-3. Level of adoption and access to social capital scatter plots.

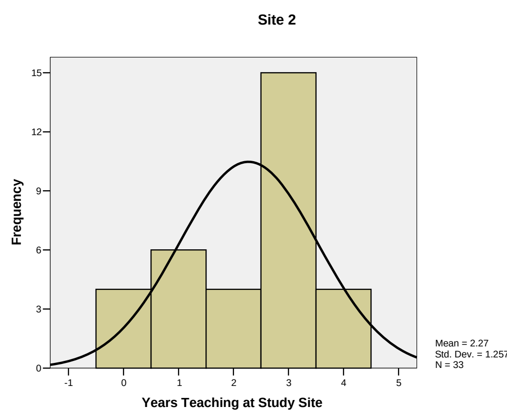

Site 1
Frequency
0
3
6
9
12
15
20
30
40
50
60
Age
Mean = 35.64
Std. Dev. = 7.687
N = 36


Site 1
Frequency
0
2
4
6
8
10
12
0
5
10
15
20
25
Years of Teaching Experience
Mean = 8.05
Std. Dev. = 5.326
N = 39


Site 1
Frequency
0
2
4
6
8
10
-2
0
2
4
6
8
10
12
Years Teaching at Study Site
Mean = 3.1
Std. Dev. = 3.243
N = 39


Site 2
Frequency
0
1
2
3
4
5
20
30
40
50
60
70
Age
Mean = 42.18
Std. Dev. = 9.942
N = 33


Site 2
Frequency
0
2
4
6
8
10
0
10
20
30
40
Years of Teaching Experience
Mean = 12.82
Std. Dev. = 9.639
N = 33


Site 2
Frequency
0
3
6
9
12
15
-1
0
1
2
3
4
5
Years Teaching at Study Site
Mean = 2.27
Std. Dev. = 1.257
N = 33

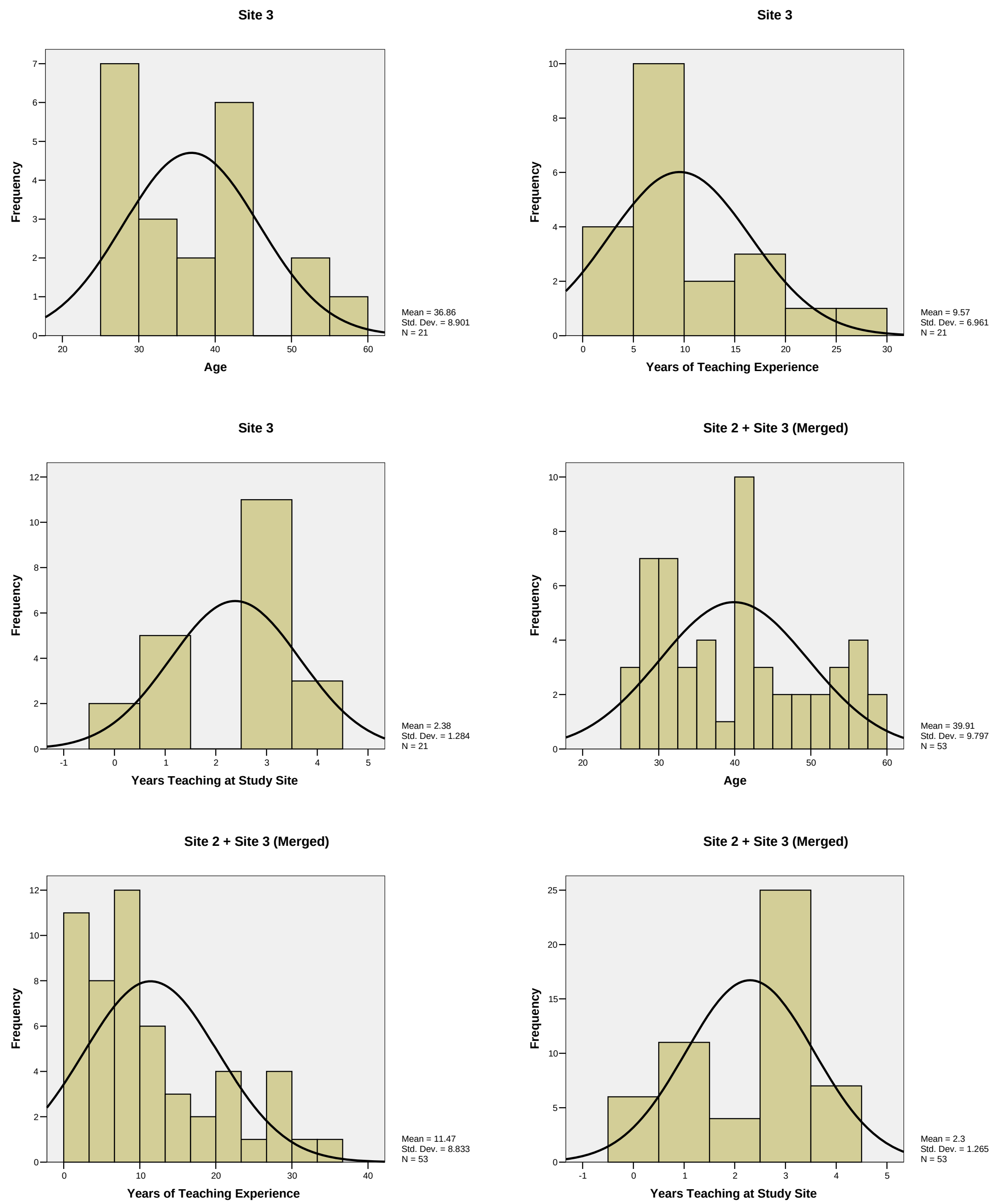


Figure N-4. Distribution of potentially confounding variables histograms