TEACHERS' PEDAGOGICAL BELIEFS AND THE INSTRUCTIONAL USE OF TECHNOLOGY WITH MIDDLE SCHOOL STUDENTS

by

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The nexus of educational reforms and rapid technological changes poses challenges for teachers in deciding why, when, and to what extent they should integrate technology into the curriculum. This exploratory study analyzed 165 middle school mathematics teachers' responses to an online survey examining their pedagogical beliefs, training, and access to technology and the use of technology by students in the classroom. Multiple linear regression was used to test three different models to predict the frequency and type of technology use by students. In addition, responses to constructed-response questions on the survey provided qualitative data to further explore this topic.

Findings indicate that the best model to predict frequency of students' technology use is one that includes access to computers in the classroom and the lab, and teacher training. This model accounted for 17% of the variance in frequency of use by students, with computer lab availability being the strongest predictor. The best model of how many types of technologies teachers reported their students using was a combination of teachers' training in technology and access to computers in the lab. Together, these two variables accounted for 9% of the variance in the number of different types of technologies teachers reported using with their students.

Pedagogical beliefs were a non significant variable, but teachers reported changes in their teaching due to students' use of technology, which included instructional practices that are associated with both didactic and constructivist pedagogies. Implications of this study are that technology resources need to be more accessible, and teacher training in technology should be timely and appropriate to available resources and curricular objectives. In addition, if mandated computerized testing limits students' access to computer labs, resource planning should consider alternatives so that students can meet technology literacy goals. Limitations of the study are presented and suggestions for future research are included.

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CHAPTER I

INTRODUCTION

Public school teachers play an important role amid educational reforms that increasingly promote technological skills and knowledge as a necessary part of a student's education. As a consequence, teachers face challenges in why, how, and to what extent they should integrate technology into their classroom environments to promote student use of technology. In the midst of these changes, how might the beliefs and practices of teachers affect students' opportunities to use and develop their technology skills?

I begin this introduction section by explaining why student technology use has become an educational imperative over the last 25 years. Then, I examine the problem of why students' use of technology in schools might still be limited despite seemingly substantial technology resources. Next, I take a closer look at how teachers' pedagogical beliefs may influence the amount and types of technology they integrate into the classroom. I end this section with the rationale for the present study and the research questions I used to focus my work.

Technology as an Educational Imperative

Student technology use became an educational imperative with the release of *A Nation at Risk*. In this influential 1983 report, the National Commission on Excellence in

Education recommended computer science as a required high school course to support the re-emphasis of math and science education to keep America competitive in the world (Christensen, Horn & Johnson, 2008; U.S. DOE, 1983; Wenglinsky, 2005). Subsequent reports, such as *What Matters Most,* published in 1996, recommended improvement of the teaching workforce to prepare itself to teach with technology and to prepare the students intellectually to use technology (Wenglinsky, 2005). The assumption was that technology use involved higher-order thinking, such as interpreting data, reasoning, writing, solving real-world problems, and conducting scientific investigations—all skills considered necessary to help American students be competitive globally (Becker, 1994). In the view of technology advocates (including national technology organizations and the federal and state governments), computers and other technologies could conceivably increase productivity and efficiency in schools, as well as provide students with advanced skills.

National Technology Organizations

Two well-respected national organizations have been stewards and advocates of technology in education since the early 1990s, each with different perspectives as to what is meant by "technology" and what curriculum standards are essential for students. The International Technology Education Association (ITEA) views technology in a broad sense as "the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs" (ITEA, 2003, p. 10). In contrast, the International Society for Technology in Education (ISTE) views technology more narrowly, as "computers, audiovisual equipment, and mass media, as tools to enhance and optimize the teaching and learning environment in all school subjects" (Dugger & Naik, 2001, p. 32). The science and engineering communities tend to promote the standards and curriculum of the ITEA, whereas the kindergarten through twelfth grade (K-12) educational community affiliates more with the ISTE. However, Petrina (2003) argued that the broadly defined technology curriculum of the ITEA and the computer-oriented curriculum of the ISTE were indistinguishable in practice. In a further comparison, according to a 2002 Gallup poll, over two-thirds of the American public have a very narrow view of the idea of *technology*, understanding it to mean activities connected to computers and the Internet (Rose & Dugger, 2002). For the most part, technology in this study relates to the ISTE understanding of technology – computers and related equipment for creating media, communicating, and enhancing the teaching and learning environment. Many references that follow are not so narrowly defined, and may incorporate a more generic or broader use of the term.

Federal Government's Role

The federal government has supported technology initiatives through targeted funding and guiding legislation. The federal government established two primary goals for technology implementation by schools: (a) to ensure that all students have computer and Internet access at school, and (b) to prepare students with "information age" skills to compete in a global economy (Metiri Group, 2006; No Child Left Behind Act of 2001).

First goal: Computers and Internet at school. United States government funds were made available with the passage of the Information and Technology Act of 1992, the Telecommunications Act of 1996, and the No Child Left Behind Act of 2001 [NCLB] to equip schools and classrooms with computers and to provide Internet access in every classroom (Garson, 2003). Technology expenditures for schools in 2003-04 were estimated at $7.87 billion (Quality Education Data as cited in USDOE, 2007). As a result, in the last decade computer and Internet access in schools increased dramatically. The latest national estimate of student to computer ratio is less than 4:1, compared to 12:1 in 1998, although ratios vary considerably according to school type and location (Wells & Lewis, 2006). The National Center for Education Statistics [NCES] (2003) reports that 99% of all schools in America and 92% of all American classrooms have Internet access.

The 2008 federal budget for technology reflected congressional sentiment that the goal of computer and Internet access for all students in school has been met. To illustrate, the annual funding for the Educational Technology State Program, which provided block grants to states, decreased from $700 million in 2001 to $267 million in 2008 (U.S. Department of Education [USDOE], 2008). On the surface, the national statistics appear to indicate that resources have been adequately supplied for technology programs to provide access to hardware, software and the Internet.

Second goal: "Information-age" skills. To achieve the second goal of information-age skills, NCLB mandated that "Every student be technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location or disability" (Section 2402). In practice, however, this language leaves a great deal open to interpretation, because each state must determine what "technological literacy" means, how this type of literacy can be measured, and how students can gain these "information-age skills."

To help schools prepare students with information-age skills, such as global awareness, communication skills, information and visual literacy, scientific reasoning, creativity, and others (Metiri Group, 2006), the federal government provided funds for teachers' professional development. Programs such as the Enhancing Education through Technology State Program provided funding to train teachers on how to use technology in their curricula. Using data from the U.S. Department of Education and the Integrated Studies of Educational Technology, Ertmer (2005) reported that 81% of teachers thought that they had adequate levels of access to instructional computers, and 85% of teachers reported feeling "somewhat prepared" to use technology for instruction. Teachers' perceived technological proficiency suggests the government-sponsored professional development programs have been somewhat successful. Compare this level of confidence with the report in the year 2000, when only about 50% of teachers reported using computers for classroom instruction at any time during the year (NCES, 2000).

If teacher instructional use has increased, teacher knowledge on integrating different types of technology and providing for students to use technology are still in question. In the Integrated Studies of Educational Technology surveys (USDOE, 2003), over 80% of teachers indicated that professional development to learn how to integrate technology into the curriculum was their greatest need. The student computer activities the teachers reported most often were: "expressing themselves in writing, improving their computer skills, doing research using the Internet, using computers as a free-time or reward activity, and doing practice drills" (USDOE, 2003), and these uses might be considered low-level uses (Ertmer, 2005). Student use is often related to teacher knowledge as well as access to resources. For example, Becker (2000) reported that when comparing groups of technology-using teachers, student use increased substantially with teachers who had both an average level of computer knowledge and access to a convenient cluster of computers. In addition, student technology use at school is often not thoroughly distinguished from technology use at home (Russell, O'Brien, Bebell, & O'Dwyer, 2003), or student technology use at school is not differentiated from teachers' instructional use (Bebell, Russell, & O'Dwyer, 2004). These apparent discrepancies show that the use of technology in the classroom is more complicated than the broad statistics reveal.

Statement of Problem

Despite significant expenditures on technology and dramatic increases in access to computers and the Internet, students' use of technology in schools is limited (Cuban, 2001; Russell, O'Brien, Bebell, & O'Dwyer, 2003). In fact, students report using more technology outside the classroom than inside it (NCES, 2000). As mentioned previously, if "information-age" technology skills and knowledge are viewed as vitally important in preparing American students to compete globally, why are students not using technology regularly in the classroom? What barriers prevent teachers from including technology as part of their curricula?

External and Internal Barriers to Technology Integration

Technology integration refers to "the process of determining which electronic tools and which methods for implementing them are appropriate responses to given classroom situations and problems" (Roblyer, 2006, p. 9). Other ways to refer to technology integration might be using technology as a tool for teaching and learning (Barron, Kemker, Harmes & Kalaydjian, 2003; Norum, Grabinger, & Duffield, 1999) or adoption and use of technology in the curriculum by teachers and students (Albion & Ertmer, 2002). For this study, I use the term *technology integration* to mean how teachers create opportunities for students to use technology in the classroom. In addition, the term technology is often vaguely defined or all-inclusive in the literature; in this study technology is generally meant to refer to computers and their various uses. By exploring teachers' technology integration, I seek to understand better the frequency and variety of student computer use in the classroom.

Researchers have identified numerous factors that inhibit the degree to which teachers integrate technology in the classroom. Ertmer (1999), drawing on the work of Brickner, frames two types of barriers to technology integration:

> ...first-order and second-order. First-order barriers are *extrinsic* to teachers and include lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support. In contrast, second-order barriers are *intrinsic* to teachers and include beliefs about teaching, beliefs about computers, and unwillingness to change. (p. 48)

Other extrinsic barriers that influence teachers' integration of technology include large class sizes, inadequate institutional support, lack of student computer skills, and lack of a district vision for technology (NCES, 2000; O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004; Strudler, 1995). Additional examples of extrinsic barriers include feeling pressure to cover a large quantity of curriculum, preparing for standardized testing, and lacking the time to learn new software programs (Higgins & Russell, 2003). Some educators may consider short time periods for classes to be an obstacle, especially in the secondary school environment, because short periods do not easily accommodate computer use by students involved in complex, project-based activities.

To overcome external barriers, schools and districts have provided more hardware and software, examined administrative policies, and provided workshops to build teacher technological skills (Brinkerhoff, 2006). Yet, despite extensive efforts by schools, research shows that efforts to overcome extrinsic barriers have not been enough to insure technology integration in the classroom (Inan, Lowther, & Ross, 2007; Wenglinsky, 1998). Strudler (1995) found that sufficient time, training, and technical support did not always overcome integration obstacles. Even after seven years of support from technology coordinators, teachers still felt that the benefits of technology integration did not outweigh the costs in time and resources. O'Connor, Goldberg, Russell, Bebell, and O'Dwyer (2004) found that less than 30% of middle school teachers felt that the district goals of putting computers in the classroom was a great incentive to their increased technology integration.

However, Cuban (1993) argued that extrinsic barriers to technology integration are plausible but superficial, requiring only a willingness to spend the money for equipment, training, etc. Instead, Cuban cited two fundamental reasons for the slow integration of technology into the classroom. The first reason is a different type of barrier, namely, that schools have a unique structure of age-graded classes, compartmentalized in classrooms that isolate students and especially teachers. His second reason, an intrinsic barrier, was teachers' cultural beliefs about "what teaching is, how learning occurs, and what is proper in school" (p. 186). Cuban explained that the traditional school structure and the time-honored teacher-student relationship were in a sense incompatible with a computer culture. Teachers feared diminishing the typical classroom teacher-student relationships or believed that adopting technology would disrupt the time-honored traditions of teaching (Cuban, 1993; Norum, Grabinger, & Duffield, 1999).

Ertmer (1999, 2005) suggested that intrinsic barriers were associated with underlying beliefs about the nature of teaching and might not be detected or easily understood, and therefore, were more difficult to overcome. Overcoming intrinsic barriers may require a "radical shift in both teaching style and the teacher's vision of what classroom life is all about" (Kerr, 1996, p. 24). The tensions over technology integration prompted Robertson (2002) to ask some fundamental questions: "Is there a philosophical conflict between teachers and educational technologists? Is there something intrinsically unsuitable in the nature and general purpose of microcomputers as learning tools?" (p. 407). These intrinsic barriers may be affecting the extent and manner in which teachers allow technology use by students.

Teachers' attitudes about education–about schooling, teaching, learning, and students–have generally been referred to as teachers' beliefs, and these beliefs are intimately connected to teaching methods (Magnan & Tochon, 2001; Pajares, 1992). Teachers' beliefs about teaching are formed from years of observing teaching in numerous situations including when teachers were students themselves, as pre-service teachers, and from their own years of teaching. Such beliefs are resistant to change (Fullan, 2001). Cuban, Kirkpatrick, and Peck (2001) argued that teachers' adoption of technology was related to their views about what constitutes the best methods of teaching and learning, "The beliefs and values that teachers hold drive many of the choices they make in the classroom" (p. 169). This collection of beliefs form a philosophy of teaching and learning and are referred to as a teacher's pedagogy (Becker, 2000).

Pedagogy and Technology Integration

Computers and other technology tools do not seem to beget any particular teaching perspective and can be manipulated by designers and users of programs for multiple purposes, yet Schofield (1995) claimed that they represent a degree of determinism. Yeaman (2004) concurred with Schofield and explained, "Each technology comes to life in its own way, not only being dependent on people but also shaping what they can do, what they want to do and, at times, what exactly is accomplished" (p. 17). In essence, integrating technology takes a certain amount of commitment to change the status quo. Computers offer new ways of learning and threaten to change teachers' classroom roles and the way in which they structure educational experiences (Andrews & Hakken, 1977; Schofield, 1995). These statements lead to an essential question: Does a teacher's pedagogy serve a gate-keeping function, controlling a student's opportunity to gain technological skills that some feel are necessary for success in the information age? An overview of two of the most popular pedagogical models in the United States may offer insights relevant to this question.

Two overarching pedagogies (didactic and constructivist) have dominated teaching in America, each representing a “different and somewhat incompatible model,” (Ravitz, Becker & Wong, 2000, p. 3) and a different theory of learning (Cuban, 1993; Windschitl, 2002). A brief iconic description of each approach follows, though it is important to remember that in reality teachers using these approaches can be more and less extreme in their pedagogical leanings, and also often blend techniques:

1. A *didactic* approach to teaching and learning is often referred to as traditional or transmission teaching. Using this approach, the teacher directs instruction, elicits objective viewpoints, and develops narrowly defined skills. Students learn the basics through practice, work alone, and are typically assessed through testing. A teacher using a didactic approach might lecture about a mathematics problem, such as solve for *x,* and then have students solve more problems of the same type on a computer (Becker, 2000; Ertmer, Gopalakrishnan & Ross, 2001; Wenglinsky, 2005).

2. A *constructivist* approach to teaching and learning occurs in unstructured environments, emphasizing whole concepts and presenting complex problems. Students often manipulate objects, work in groups, and are assessed through projects by means of rubrics. A teacher using a constructivist approach might give students the task of representing daily temperature data on a computer-generated graph (Becker, 2000; Ertmer, Gopalakrishnan, & Ross, 2001). In a constructivist classroom, computers have broad capabilities to provide complex problems in unique ways that cannot be replicated without them (Wenglinsky, 2005).

Two large-scale studies, one conducted at a national level and the other a 3-year longitudinal study conducted at a state level, have taken a closer look at how teachers' pedagogy influences technology integration in the classroom. Both of these studies were extremely large in scope, examining technology access, resources, and the perspectives of principals, teachers, and students. In both, one of the primary purposes was to examine the role of teachers' pedagogy in relation to students' use of technology in the classroom.

In the *Teaching, Learning, and Computing Study* (TLC), Becker and Anderson (1998) surveyed 4,083 teachers (grades 4-12) from 2,251 schools. Using data drawn from the TLC survey, Becker (2000) found a clear relationship between teaching pedagogy and the frequency and types of software used by students, especially with the most constructivist teachers. Teachers who were the most highly oriented toward constructivist pedagogy assigned *more* student technology activities and involved students in more *types* of activities that required higher-level software than did didactic-oriented teachers. Additionally, teachers' use of computers with students over time influenced their teaching pedagogy toward more constructivist practices (Ravitz, Becker, & Wong. 2000). Over time, teachers who used a large variety of software, used the Internet frequently in their teaching, and assigned collaborative computer work to students shifted toward constructivist pedagogy. The potential to shift pedagogical beliefs creates some intriguing questions as to whether pedagogical beliefs must precede practice or whether beliefs can be influenced by successful practice (Ertmer, 2005).

Several notable limitations of the TLC study need to be mentioned. Teachers were selected in a way that disproportionately sampled those who made substantial use of computers, who had students do project work, and who emphasized higher-order thinking in their teaching. If using technology is associated with a more constructivist approach, it would be important to find out whether a teacher's pedagogy relates to technology use in the "typical" classroom. Also, the study included teachers in elementary, middle, and high school, but analysis of teacher pedagogy and student computer use merged middle school and high school into one category, termed secondary level. Therefore, it is difficult to get a clear picture of what happened with student technology use at each level.

In a three-year study partly modeled on the TLC report, researchers at Boston College joined with 22 Massachusetts school districts to examine the extent and type of technology use by teachers and students in the classroom and at home (Russell, Bebell & O'Dwyer, 2003). The *Use, Support, and Effect of Instruction Technology* (USEIT) study included districts that had strong technology programs in place. Researchers surveyed teachers (*n* = 4,308); students in grades 4, 8, and 10 (*n* = 13,388); and principals (*n* = 116). The USEIT schools had a slightly higher student to computer ratio (6.7 students per computer) than the statewide average (4.8 students per computer), but they had fewer minority students and fewer students on free and reduced-price lunch than the statewide average.

The USEIT researchers developed their surveys using several scales from the TLC survey, which included items developed to measure didactic-constructivist teacher pedagogy. They also found support for a relationship between teachers' pedagogy and the extent and type of technology use by teachers and students in the classroom (O'Dwyer, Russell, & Bebell, 2004). Teachers who held constructivist beliefs were more likely to have their students use technology more frequently in class, and to create products. The

USEIT study also disproportionately sampled schools that had made efforts to establish technology programs.

Framing This Study

In previous research on teachers' pedagogy and student use of technology, researchers have used survey methods to sample teachers across grade levels, across subject areas, and across states but less often throughout one state at one level and in one subject. Additionally, these studies have tended to use samples of teachers from schools that had established technology programs (Russell, O'Dwyer, Bebell, & Miranda, 2004) or constructivist, technology-using teachers (Ravitz, Becker, & Wong, 2000). In contrast, in this study, I sampled teachers from one state, with the goal of reaching as close to a representative group of 7th and 8th grade mathematics teachers as possible in regular public school circumstances.

Choice of Mathematics

As one of the core academic subjects, mathematics is often studied as a bellwether of school, state, and national academic health. Furthermore, it appears to be an unlikely discipline to select for a study involving constructivism. Mathematics is the classic example of knowledge "shaped by the objective properties of number systems and the requirements of deductive logic" (Phillips, 2000, p. 5), especially when compared to language-oriented subjects. But according to Phillips (2000), research trends in cognitive psychology (which would include the topic of constructivism) have emphasized the content areas of mathematics and science. Potentially mirroring the distinction between didactic or constructivist pedagogy, Davis (1984) argued that mathematics programs can take on a “rote” characteristic or emphasize more “meaningful mathematics”. Therefore, the mere recognition that constructivist theory might apply to mathematics is important to mention in regards to the current study.

Mathematics is characteristically sequential in most school programs (Ruthven, Hennessy, & Brindley, 2004) and has long been predominated by the use of didactic pedagogical approaches. Wenglinsky (1998) claimed that the middle grades are an opportune time to study higher-order thinking in math in relation to technology using constructivist approaches, explaining that higher-order mathematical concepts are not introduced until middle school and the “primary benefit of computers lies in applying higher-order skills” (p. 36). Yet one of the goals of schools is to educate students for the workforce, “and that workforce is not neutral about pedagogy” (Wenglinsky, 2005, p. 14). Society expects schools to develop students who have 21st century information age skills, such as in problem-solving, communication, and creative thinking, which are valuable when working in teams. These are all goals of constructivist pedagogy (Wenglinsky, 2005).

The national standards that guide mathematics instruction include extensive constructivist language. For example, in describing the curriculum focal points for grades K-8, the National Council of Teachers of Mathematics (NCTM) states, “It is essential that these focal points be addressed in contexts that promote problem solving, reasoning, communication, making connections, and designing and analyzing representations” (NCTM, n.d.). Although research has shown mathematics to have didactic, sequential, and even low technology-related tendencies (Ravitz, Becker & Wong, 2000), the standards demonstrate that mathematics educators at the national level have broader, more constructivist visions.

Choice of Grade Level

Comparing data between studies becomes problematic when a "middle school" designation is used because different grade levels are often included in the term. Depending on the school district, the 6th grade level might be included as either elementary level or middle school data. Middle level schools are also considered "secondary level," or called "junior high," which may include the 9th grade level. Thus, it is sometimes unclear what grades are included in the research. To eliminate confusion, I decided to select just two grades typically included in middle schools for my research. For clarity, in this study I will use the term "middle school" to include only teachers from 7th and 8th grades.

One benefit of choosing middle school for analysis is that they have a characteristic of time-bounded periods that is unlike the self-contained classrooms of elementary school and more like a typical high school structure with six or seven periods a day, or a block schedule. Middle schools may have time periods that are single or double periods (i.e., block schedules), with single periods being more prevalent. But compared to elementary teachers, middle school teachers might have an easier time determining the use of technology in a single subject, in well-defined periods, than in the day-long interactions of a self-contained classroom.

The choice of 7th and 8th grade also fits well with the goal of the *No Child Left Behind Act* (NCLB), which states that students should be technologically literate by the end of 8th grade. Logically, reaching a goal by the end of 8th grade requires some type of technology integration effort in previous grades, so it seems appropriate to include both 7th and 8th grade teachers in my study.

Choice of State

The selection of the state from which to draw the teacher sample for this study was significant for several reasons. This state, located in the Pacific Northwest, was ranked in the bottom 5% in the nation by Editorial Projects in Education Research Center (2008), which conducts annual state-by-state analysis of technology access, use and capacity. However, in terms of technology resources, the state sampled in this study has mandated computerized testing, so computer resources are considered to be sufficient. The state's student to computer ratio of approximately 5 students per computer (Oregon Department of Education, personal communication, April 23, 2009) is slightly higher than the national average of approximately 4 to 1 and slightly lower than the USEIT study in Massachusetts, which had a student to computer ratio of 6.7 to 1.

Furthermore, although the state does not have technology-related licensure requirements for teachers or administrators, it has recently adopted educational technology standards for students (Oregon Department of Education, 2008). The recently adopted educational technology standards follow the guidelines of ISTE and are listed here to provide a context for the reader to understand student skill level expectations:

1. Creativity and Innovation: Students demonstrate creative thinking and problem

solving skills to develop innovative products and processes using (digital) technology

2. Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, across the global community, to support individual learning and contribute to the learning of others.

3. Research and Information Fluency: Students select and apply digital tools to gather, evaluate, validate, and use information.

4. Critical Thinking, Problem Solving and Decision Making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.

5. Digital Citizenship: Students understand human, cultural, and societal issues related to digital technology and practice legal, ethical, and responsible behavior.

6. Technology Operations and Concepts: Students utilize technology concepts and tools to learn.

Research Questions

The purpose of my study is to build on previous research with this overarching question: *What is the relationship of teachers' pedagogical beliefs to the frequency and type of students' technology use in 7th and 8th grade mathematic classrooms in the state of interest?* To address this question, I examine the following, based on prior published research:

- The degree to which pedagogical beliefs are related to frequency of student use of technology in the classroom. Prior research suggests constructivist teachers involve their students in more technology-related activities than didactic teachers.

- The degree to which pedagogical beliefs are related to types of student use of technology. Prior research suggests constructivist teachers involve their students in a greater variety of technology related activities than didactic teachers).
- Finally, researchers report that adequate and convenient access to computers is a significant predictor of student use of technology, so this is investigated as well.

CHAPTER II

REVIEW OF THEORY AND LITERATURE

In the following section, I establish the theoretical framework of this study by anchoring two teacher pedagogies (didactic and constructivist) within philosophical and psychological perspectives. I describe how both philosophy and psychology have helped shape teaching and learning in America. Then, I describe how students' computer use in education has evolved. Finally, I connect teacher pedagogy with student use of technology, a connection that guides the study.

Theoretical Framework

The contrast between didactic pedagogy and constructivist pedagogy is, at its core, a fundamental difference in theories of student learning. This difference can be conceptualized as "the difference between learning through reception of facts and repetitive practice of discrete skills versus learning through effortful integration of new ideas with those previously believed" (Ravitz, Becker & Wong, 2000, p. 3). Pedagogical beliefs and student learning are influenced by different philosophical and psychological perspectives about what knowledge is, as well as how it is acquired and retained.

Didactic Pedagogy

Epistemology, a philosophical approach to studying the origin of knowledge (what it is and how it is acquired), and empiricism and objectivism, two perspectives on these questions, have strongly influenced didactic teaching philosophy in Western societies. Both empiricism and objectivism have shaped the didactic teaching philosophy seen throughout American schools.

Empiricism is based upon the belief that all knowledge comes from experience. “The mind passively receives experience and is active in knowledge construction only *post hoc,* as it were, only in the sense of ordering what is already *given* in experience” (Howe, & Berv, 2000, p. 20). John Locke (1963), the influential British philosopher, described an individual’s mental development as starting with a “white paper” even an “empty cabinet,” which becomes filled with each successive experience, building into more complex ideas (p. 82).

Objectivism, a complementary perspective, assumes that knowledge is stable with essential properties of objects as knowable and relatively unchanging (Windschitl, 2002). The real world provides a model from which to learn. The purpose of the mind is to "mirror" that static reality and its structure through “analyzable and decomposable” thought processes (Jonassen, 1991, p. 9). Objectivism views the world as existing outside and independent of the knower. The role of education is, therefore, to assist the learner in “assimilating” this real world (Jonassen, 1991, p. 10). This assimilation results in knowledge creation, or learning (Cooper, 1993).

Empiricism and objectivism fit well with behaviorism, a field of psychology that emerged in the early 1900s. This psychological approach deemphasized the mind and exalted observable behavior as the sole indicator of human learning. Behaviorism was the first objective scientific attempt to explain how humans learn (Watson, 1958), a process which was previously left to introspection. Early behaviorists concluded that learning was an association between a stimulus and a response. By stimulus, Watson (1958) meant "any object in the general environment or any change in the tissue themselves due to the physiological condition of the animal" (being hungry) (p. 6). A response was "anything the animal does" (reacting to noise, climbing, painting, reading, etc.) (p. 6). Animals (including humans) are constantly exposed to all sorts of stimuli through the senses, muscular system, and visceral system, and some reactions become "habituated," emerging over time through conditioning (Watson, 1958). Conditioning was described as a process of developing and strengthening new associations between stimuli and responses.

Edward Thorndike, an early behaviorist whom some researchers consider the initiator of "informed instruction" (a systematic and sequential approach to instruction), suggested that learning took place through the "differential strengthening of bonds between situation and actions" (Palinscar, 1998, p. 346). By this, he meant that what comes after a response (the consequence) influences learning. Thus, "learning is a change in the behavioral dispositions of an organism" that is shaped by selective reinforcement (Jonassen, 1991, p. 5). Because learning was shaped by external influences (i.e., the environment) and observable, behaviorists such as Watson and B.F. Skinner denied the existence of a mind that was distinct from the brain; mental operations were not observable (Adler, 1990). Behaviorists explained thinking as speaking to oneself, since speaking was considered to be a type of observable behavior (Watson, 1958).

B.F. Skinner (1954) extended Thorndike's work in developing the theory of operant conditioning, in which he argued that learning is the process of behaving in ways that produce desired outcomes, which he termed conditioning. For Skinner, teaching was simply a matter of shaping behavior by reinforcing a series of responses. The idea that humans could be shaped at will by the schedule of reinforcement led to "instructional procedures such as modeling, demonstrations, and reinforcement of closer approximations to the targeted response" (Palincsar, 1998, p. 346). Academic curriculum, therefore, required a carefully designed scope and sequence of skills, each learned one at a time with prerequisite skills needing to be mastered before moving on (Palincsar, 1998). The teacher's role was to shape the pupil. The teacher, who is on center stage, controls all curricular circumstances and "in a face-to-face reasonably formal manner, tells, shows, models, demonstrates, and teaches the skill to be learned" (Baumann, 1988, p. 714). Such teaching behaviors are characteristic of didactic pedagogy.

Didactic pedagogy has been well documented by educational historians and is so prevalent in American education that it is often called "traditional teaching." In her study of American schools from 1820 -1880, Finkelstein (1989) described teachers having dogmatic control over the progress of their students, "organizing classroom activities in such a way as to force each student to systematically practice skills and acquire knowledge from carefully defined, skillfully blocked-out, and predetermined courses of instruction" (p. 41). She categorized teachers into three patterns: (a) the intellectual overseer, who assigned work, tested students' memorizations, and upheld standards; (b) the drillmaster, who led students through recitations in choral fashion, and (c) the interpreter of culture (a rarity), who clarified ideas and explained content to the children. In all types of public schools–small or large, rural or urban–in all areas of the country, teachers taught with the belief that

> ...all knowledge, from reading to arithmetic, comprised collections of facts–absolute, unchanging and true. They did not seem to regard knowledge as provisionally held and progressively realized, as constantly changing and as subject to manipulation. The task of the student was to learn the material. The task of the teacher–essentially moral, rather than intellectual–was to make students learn. (p. 137)

The teacher as the transmitter of a fixed body of knowledge and the student as the passive receiver of this knowledge reflects the philosophical influence of empiricism and objectivism. This didactic type of teaching is often referred to as teacher-centered. Cuban (1984) documented the high prevalence of teacher-centered pedagogy, especially in secondary schools, in his analysis of a century of American education (1890 -1990). Teachers held institutional authority, transmitted knowledge to students, maintained quiet, orderly classrooms, and placed high value on academic rigor. Becker (2000) provides an outline of the primary precepts of didactic pedagogy:

> (a) The use of externally prescribed curriculum of discrete skills and factual knowledge, (b) direct presentation and explanation to students of that procedural and factual knowledge, (c) frequent assignments of written exercises to students aimed at their remembering factual knowledge and accurately performing skills, and then; (d) evaluation of students' mastery of skills and knowledge by giving them written tests that prompt students to recognize factual statements and to apply learned algorithms and other skills to produce correct answers. (p. 9)

This description clearly reflects the combined influences of objectivism, empiricism, and behaviorism: Knowledge consists of a discrete fixed body of knowledge that must be deduced into component skills and transmitted to the student. The students' role is to absorb this knowledge and to practice it until learned. In contrast, constructivists criticize didactic pedagogy for not fully recognizing the true nature of knowledge and learning. Constructivists view knowledge as less fixed and human learning as a more active process.

Constructivist Pedagogy

Constructivist pedagogy is grounded in rationalism, the philosophical counterpart to empiricism. Rationalism is based upon the belief that the mind is an active contributor to the construction of knowledge, not simply an organizer of experience. The mind "contributes more than merely ordering what is already given" (Howe & Berv, 2000, p. 20). The essence of rationalist philosophy was that knowledge can be found by "looking within one's self" (Anderson, Reder & Simon, 1998, p. 228). Rationalists believe a person learns by creating new mental structures (e.g., interpreting new information) and by reorganizing prior beliefs and knowledge, individually or with others (Anderson, Reder, & Simon, 1998; National Research Council, 2000; Windschitl, 2002).

Immanuel Kant, a preeminent philosopher of the 18th century, tried to reconcile both rational and empirical perspectives, and according to some researchers he was the first "true" constructivist (Bredo, 2000). Kant viewed both perspectives as contributing to a collective view of knowledge that can be agreed upon to the extent that we share the same world. He argued that in the construction of knowledge, concepts and experiences cannot exist independently (Anderson, Reder, & Simon, 1998; Howe, & Berv, 2000).

Constructivism, in contrast to objectivism, represents a shift away from an external view of reality to one in which reality is viewed as an internal construction (Bruner, 1966; Cooper, 1993; McCarty & Schwandt, 2000). The mind uses symbols as tools to represent the knower's reality. A learner's prior knowledge, attitudes, and interests interact with new experiences as the learner "constructs" his or her own, perhaps unique, understandings, no longer exemplified as a passive learner being fed information (Howe & Berv, 2000). Constructivists argue that there is no objective reality separate from the mind of the learner and that the world is subjective, a product of each individual's perception, and therefore different for each person. Therefore, learning should be *situated* in the real world, involving real world contexts (Jonassen, 1991).

These philosophical tenets were compatible with developments in psychology that emerged in the middle of the 20th century, which emphasized mental operations and language. Psychologists began questioning the behavioral principles of reinforced responses that ignored internal processing (Cooper, 1993). When psychologists applied behaviorist principles to verbal learning (such as verbal memory and development of speech), the results eroded behaviorism's credibility. For example, in a series of studies testing verbal memory, researchers asked subjects to memorize nonsense syllables and repeat them after varying periods of time (Ormrod, 1999). Subjects did not merely repeat precisely what they initially learned. Instead, they created associations and connections that were not originally there. This finding demonstrated that humans have a creative tendency and thus try to create meaning even when not required to do so.

Similarly, psycholinguist Noam Chomsky's (1959) defense of the complex mental processes involved in the acquisition of language countered Skinner's simplistic stimulus-response explanation of language development. Chomsky stated:

> As far as acquisition of language is concerned, it seems clear that reinforcement, casual observation, and natural inquisitiveness (coupled with a strong tendency to imitate) are important factors, as is the remarkable capacity of the child to generalize, hypothesize, and 'process information' in a variety of very special and apparently highly complex ways which we cannot yet describe or begin to understand, and which may be largely innate, or may develop through some sort of learning or through maturation of the nervous system. (p. 43)

The results of this research on verbal memory and language, along with the emergence of an alternative learning theory–cognitivism–began to weaken the behaviorists' influence on teaching and learning.

Gardner (1987) defined cognitivism as "a contemporary, empirically based effort to answer long-standing epistemological questions–particularly those concerned with the nature of knowledge, its components, its sources, its development, and its deployment" (p. 6). He and others argued that humans construct mental representations and manipulate them through internal or external language or symbolic languages like mathematics (Bruner, 1966; Gardner, 1987; Jonassen, 1991). Mental events cannot be observed, so learning (such as a student understanding a mathematical concept) must be inferred by the person observing behavior (Bruner, 1960). Whereas the behaviorist principles of learning emphasize the repetition of knowledge and skills learned, cognitivists emphasize the creation of something new or more complex using the collection of old and new knowledge.

Two well-known developmental psychologists, Jean Piaget and Lev Vygotsky, conducted research in the 1920s that gave impetus to cognitivism (as well as constructivism) as an alternative to behaviorism. Piaget believed that the mind was a connective tool to the real world, allowing individuals to create more sophisticated mental representations and problem-solving abilities by using tools, information resources, and input from other individuals (Jonassen, 1991). Learning occurred in a process of assimilation and accommodation of new experiences in the following manner (Anderson, Reder, & Simon, 1998):

> Assimilation incorporates experience passively into a representation already available to the child. However, when the discrepancies between task demands and the child's cognitive structure (representation) become too great, the child must reorganize his or her thoughts. This is called accommodation, recently renamed "re-representation". (p. 235)

Vygotsky emphasized social relationships in learning. He proposed a cognitive developmental model based on social interactions. Children achieve maximal cognitive growth by learning from those persons who are more competent than themselves. Specifically, the difference between a task that a child can accomplish independently and a task that a child can perform with the help of someone else (expert or adult) is called the zone of proximal development (Ormrod, 1999). Social constructivism emphasizes the social, cultural, and contextual influences on learning (Anderson, Reder & Simon, 1998; Bredo, 2000). Vygotsky viewed "symbolically mediated thought as a social process, like a dialogue, that is “internalized” through participation in social interaction” (Bredo, 2000, p. 133). Language, in particular, helps to construct an individual’s knowledge by providing “a cultural repertoire that an individual is “born into” (Phillips, 1995, p. 5).

Bruner (1966) was distinct in his applications of cognitivism to education. He used the phrase “evolutionary instrumentalism” to describe how mankind has used technologies to extend mental development. “Man’s use of mind is dependent upon his ability to develop and use ‘tools’ or ‘instruments’ or ‘technologies’ that make it possible for him to express and amplify his powers” (p. 24). Language is the best tool, and schools, as the transmitter of skills, also fulfill the role of communicating an existing culture to each subsequent generation. Cognitivism has provided a theoretical umbrella for numerous disciplines, including philosophy, psychology, artificial intelligence, linguistics, anthropology, and neuroscience (Gardner, 1987). This learning theory is pertinent to the current study because it provides a theoretical framework for constructivist pedagogy.

Constructivist-oriented education, based upon the philosophical perspectives of the individual child as learner and social actor, has been called “student-centered” as opposed to “teacher-centered” and has a long history in the United States as a movement known as “progressive education” (Windschitl, 2002). Examples such as Francis Parker’s “Quincy System” in 1873, John Dewey’s University of Chicago Laboratory School in 1896, Helen Parkhurst’s Dalton School in 1919, and Denver’s Eight Year Study in the 1930s (Education Week, 2000; Windschitl, 2002) demonstrated instructional innovations that are seen in today’s constructivist pedagogy, such as problem-based learning, collaborative projects, and meaningful inquiry in community-based settings. John Dewey and Maria Montessori were noteworthy educational innovators whose student-centered philosophies have endured to the present day (Cuban, 1993; Education Week, 2000). Both of these educators promoted a rigorous curriculum of skills mastery combined with open-ended explorations that followed a child's motivations.

The landscape of constructivism is complex, and it is conceivable that teachers have adopted many of the practices of constructivism without fully understanding their own epistemological views (Windschitl, 2002). Critics and supporters agree that constructivism has adhered to several key principles in the educational setting that appear in a wide variety of literature on the topic: (a) students' prior knowledge, interests, and attitudes are an important starting point; (b) students are allowed to create new meanings for the content with which they interact; (c) students demonstrate an active and exploratory role in their own learning; (d) collaboration is promoted; (e) multiple points of view are respected; and (f) authentic problem-solving is emphasized (Bredo, 2000; Burbules, 2000; Howe & Berv, 2000).

Interestingly, both behaviorism and cognitivism have theoretical and practical connections to computer technology. Skinner (the preeminent behaviorist), for example, favored positive, immediate, and frequent reinforcement to influence and sustain the desired learning. However, he believed the typical teacher's role was an ineffective and out-of-date mechanism to properly control student learning because timely and plentiful reinforcement for all students was not feasible. As a solution, he promoted a mechanical or electrical device to meet the classroom challenge, a forerunner to computers called a "teaching machine," that would allow students to learn at their own pace, receiving immediate feedback to their responses (Skinner, 1954).

For some cognitive theorists, concepts of "mental representations" (symbols, schemas, images) lie conceptually between the levels of input (perception) and output (behavior) (Gardner, 1987). The terminology clearly has parallels to computer vocabulary, perhaps because the development of cognitivism was concurrent with the development of the computer. At one time, the computer was considered a reasonable model for the workings of the mind, particularly in the branch of cognitive science known as information processing theory (Ormrod, 1999). Over the brief course of its history in schools, computer technology has been utilized by both didactic and constructivist teachers as a tool that promotes student learning and engagement.

Historical Context of Technology in Schools

Electronic technologies, such as radio, film, television, and videotape recorders, have been incorporated into classrooms over time, and always with a degree of revolutionary fanfare. These technologies enhanced classroom instruction somewhat, but they did not fundamentally change the predominant model of teaching, which was didactic (Cuban, 2001). Since the introduction of computers in education around 1980, advocates have promoted the potential of technology in multiple ways. The predominance of the didactic pedagogy and the influence of behaviorism can be seen in the early days of computer use in the classroom: activities were designed to follow a carefully orchestrated scope and sequence, with each skill being reinforced by practice until learned. The computer was an "automatic teacher," delivering computer-aided instruction to assist and sometimes replace the teacher (Bosco, 1995; Roblyer, 2006).

Providing students with drill and practice in arithmetic and spelling, in essence, “the computer was being used to program the child” (Papert, 1980, p. 5).

The tedium of programmed learning soon gave way to computer programming, especially in secondary schools, where students were taught computer languages such as BASIC, LOGO, and FORTRAN (Cuban, 2001; Papert, 1980). In a 1983 national survey, Becker found that elementary school teachers tended to have students use computers more for drill and practice, and high school teachers tended to employ more programming for students. At all levels, use of computers for drill and practice decreased after a couple of years, while their use for programming increased. Teachers reported little change in their instructional practice but did note that the biggest impact appeared to be social, with computer use increasing student enthusiasm for school (Becker, 1983).

Student technology use in the 1990s shifted away from programming toward content-related purposes in the form of compact disc programs and the use of the Internet. In a 1999 large-scale national survey of public school teachers, 61% of public school teachers reported assigning word processing, 51% reported assigning Internet research, 50% reported assigning drills, and 50% reported assigning computer activities that involved solving problems or analyzing data (NCES, 2000). At that time, 84% of responding teachers had computers available in their classrooms, and about 50% of all teachers reported using computers or the Internet in their instruction. However, this seemingly substantial availability of computers and adoption of technology by teachers may be misleading because computer availability could mean a computer for teachers’ use only and “computer use” could mean as little as once a year.

Teacher and Student Use of Technology

Vague descriptions of classroom technology use in research studies ignore the complexities of technology descriptions and measurement. For instance, classroom technology use may mean that the teacher is using technology and not the students. Bebell, Russell and O'Dwyer (2004) clearly demonstrated that multiple measures of technology use were more informative than a singular generic measure. Instead of reporting a single index of technology use in the classroom, they developed seven scales of teacher use: preparation, professional e-mail, grading, delivering instruction, accommodation, teacher-directed student use, and student products. Of those seven measures, only the last two pertained to student use.

Certainly, disaggregating types of technology use in the classroom provides a clearer picture of who is using technology and how technology is being used in the classroom. To avoid the misinterpretation of technology use, I focused specifically on how students use technology in the classroom in my study. This clarification de-emphasizes teacher use (personal or professional e-mail, grading, or lesson preparation) that does not directly relate to students' use of technology. In the following paragraphs, I detail several large-scale studies that have attempted to provide a clearer description of student technology use in the classroom.

Wenglinsky (1998) examined the frequency and type of computer use by students using data drawn from the 1996 National Assessment of Educational Progress (NAEP) in mathematics. The sample consisted of 7,146 eighth-grade mathematic students. The study found that 28% of eighth graders reported using computers in their mathematics' classes at least once a week. Subgroup variation (race, socioeconomic status, location) in frequency of computer use was quite small, indicating that student access to computers seemed to be equitable. The NAEP question on type of computer use offered only three possible choices. Of these three types of use, *drill and practice* was the most commonly reported activity by students (34%), *playing learning games* was the second most frequently reported activity by students (29%), and *applications/simulations* was the third most used frequently reported activity by students (27%). Wenglinsky (1998) designated drill and practice and learning games as lower-order activities and applications/ simulations as higher-order learning activities. Large variations in type of computer use among subgroups of students were reported. For example, suburban and non-poor students used substantially more application activities than minority, poor, and urban students, who used more drill and practice.

Becker, Ravitz, and Wong (1999) sought a more detailed view of technology use by students across grade levels and subject areas. Using data drawn from the *Teaching, Learning, and Computing* (TLC) study, which surveyed 4,100 teachers (grades 4-12, across subject content areas) at more than 1,000 schools, the researchers examined frequency and type of computer use by students. Data were collected by teacher reports on how often and what types of computer use they assigned to their students. Type of computer use included 10 categories: word-processing, CD-Rom, Internet, skill and practice games, simulations/exploratory environments, graphics, spreadsheets/database, presentation, multimedia, and e-mail. Almost 49% of math teachers reported having students use computers. However, this percentage may be misleading because it included math teachers who reported they *rarely* or *occasionally* had students use computers.

The subgroup of teachers in the TLC study whose students used computers on more than 20 class days during the school year were identified as high-use technology teachers. Of this high-use technology subgroup, middle school mathematics teachers had students use computers more often than high school mathematics teachers but less often than the middle school English teachers. The researchers excluded the graphing calculator as a technology tool for mathematics teachers. This exclusion could be reasonably questioned, as graphing calculators perform many high-order tasks.

Instead of using teacher reports exclusively, the USEIT researchers also collected data from students in grades 5, 8, and 11 on the amount and type of computer use at school and home. Of eighth-grade students (*n* = 4,695), 44% reported that they did not use computers at school at any time, 30% reported using computers for 15 minutes or less per day, 24% used computers for 15-60 minutes a day, and 2% used computers for an hour or more per day. Looking more closely at these results by subject area, when asked how often they used computers in a particular class, 65% of eighth-grade mathematics students reported *never*, 22% reported *a couple of times a year*, 7% *once every couple of weeks*, and 6% *at least every week*. They reported using computers more in labs and the library than in classrooms. The researchers who conducted the USEIT study did not separate school and non-school type of use in the student survey. Therefore, student responses might include home as well as school use. For the USEIT study, researchers compiled the list of types of technology that students used from an examination of eleven surveys and a review of literature. The USEIT researchers also collected data from teachers about the frequency and type of computer activity used by students in their classes. Type of student computer use was divided into two categories (student use of technology during classtime and student use of technology to create products. Classtime technology use included: research, solve problems, educational games, games for fun, presentation, spreadsheet/database, probes, email (communication with experts or students in other schools), writing, and keyboarding. Product technology use included: multimedia projects, web pages, artwork, graphs or charts, videos.

In both the TLC study and the USEIT study, researchers found that the amount and types of student use of technology in the classroom was influenced by several classroom level factors: teachers' pedagogy, technology proficiency, and access to computers.

Factors Affecting Student Technology Use

The nexus of pedagogical beliefs and student use of technology is the focus of this study. Can a teacher's belief system, background, and/or factors in the classroom environment predict student use of technology?

Researchers have found that a teacher's instructional use of computers reflects his/her pedagogical belief system, typically relating to one of two pedagogical approaches–didactic and constructivist (Levin & Wadmany, 2006; Howard, McGee, Schwartz & Purcell, 2000; Judson, 2006; Ravitz, Becker & Wong, 2000; Windschitl, 2002). Thus, if teachers hold didactic viewpoints, they are more likely to use computers in a compatible manner (drill and practice). Conversely, if teachers have constructivist viewpoints, they are more likely to use computers in constructivist ways (simulations or application of concepts learned) (Becker, 2000; Judson, 2006).

Niederhauser and Stoddart (2001) concluded that the *drill and skill* type software programs were used most often by teachers who preferred a more didactic, teacher-centered style. *Open-ended* software was used more often by teachers whose teaching was more student-centered. One interesting decision made by Niederhauser and Stoddart was categorizing word-processing as open-ended software. Word-processing is the most frequently used software by all teachers, at all levels, but most researchers categorize it as a *lower-level* use of technology, one often associated with teachers with less technology training (Ertmer, 2005).

The results reported by Zhao, Pugh, Sheldon, and Byers (2002) support those reported by the researchers who conducted the USEIT study. Teacher pedagogical beliefs matched the type of computer use, and teachers with limited experience and a didactic approach found a "comfort level" using the type of technology where they could feel successful, which was limited and low-level. In his analysis of NAEP test data, Wenglinsky (2005) found that high-level technology uses, such as conducting simulations or applications of mathematics concepts, were associated with higher achievement in mathematics, and frequent use of lower-level type, such as drill and practice were associated with lower mathematics achievement

Ravitz, Becker, and Wong, (2000) using data drawn from the TLC survey found that elementary teachers were more constructivist in their philosophies than other teachers. Additionally, on average, middle school teachers have a more constructivist philosophy than high school teachers. In quantitative and technical subjects like math, middle school teachers were more constructivist than high school math teachers (Ravitz, Becker, & Wong, 2000). They suggest that high school teachers may have greater pressure to cover content matter in order to prepare their students for college and "feel a greater sense of ownership in the knowledge base that exists in their field" (p. 18). In addition, they found that teachers' philosophies did a good job of predicting patterns of practice. Teachers who held more constructivist beliefs than teachers of the same subject and grade level reported using more constructivist practices of all types and less didactic practices.

Becker (2000), in responding to Larry Cuban's analysis of student computer use in school, examined several factors that Cuban claimed influenced student use of computers. Using data drawn from the TLC survey, he found a strong relationship between having a cluster of computers in the classroom and how frequently students use computers. Teachers of academic subjects where the student to computer ratio was four to one showed an increased likelihood of student computer use. The only discrepancy to this pattern was in self-contained elementary classes, where students used computers more frequently in relation to the amount of computers in the classroom.

In contrast to Cuban's claim that teachers' technology skills were not the reason for low student computer use, Becker found that teachers who have a "reasonable amount of technical skill and who use computers to address their own professional needs use computers in broader and more sophisticated ways with students than teachers who have limited technical skills" (p. 7).

Validity Support From Previous Studies

In my study, I draw on three previous research studies that validated survey responses of teachers' pedagogical beliefs (Burstein et al., 1995; Ravitz, Becker & Wong, 2000; Russell, O'Dwyer, Bebell, & Miranda, 2004). One purpose of Burstein et al.'s (1995) study of mathematics curriculum was to determine the technical adequacy of teacher self-reports about teaching philosophy and instructional strategies, compared to classroom artifacts, interviews, teacher logs, and other benchmark data. Although the researchers acknowledged the difficulty of measuring teachers' pedagogy, they concluded that the survey responses were valid, and matched what the researchers observed. "The majority of teachers use a few instructional strategies and use them often. They tend to rely most frequently on lecturing and reviewing homework and rarely, if ever, engage in activities that are consistent with the mathematics reform movement, such as student-led discussions" (p. xiii). These and other researchers have pointed out that self-reported responses about beliefs, strategies, or philosophies can suffer from "social desirability bias" (Burstein et al., 1995; Ravitz, Becker & Wong, 2000; Russell, O'Dwyer, Bebell, & Miranda, 2004); however, they found that the questions on their survey appeared to be reliable estimates of observable behavior despite this caution.

A second study that provided evidence related to the reliability of teacher self-reports about their pedagogical beliefs was the preliminary validity study of the TLC survey (Ravitz, Becker & Wong, 2000), conducted with 72 teachers from 24 schools in 3 areas of the country. Participants in the study taught different subjects and grade levels. The research team correlated coded observation data with survey responses, interviewed each teacher for at least two hours, examined written assignments, quizzes, and artifacts, and had interviewers-observers take the same survey instrument as the teacher respondents (responding according to their understanding of the teacher's philosophy). Using those survey items on philosophy that correlated the highest with the observer scoring of the item, they created several indices, and reported that the median index to factor correlation was .51. These items eventually were included as a 13-item teachers' belief index in the national survey.

Although the TLC survey authors also noted the weakness of self-reported beliefs, they contended that the items on the philosophy index of the TLC survey constituted relative validity (as opposed to absolute validity). “Relative validity is the correlation across teachers in their relative placement along two measures, a survey measure and a criterion (e.g. observational) measure” (Ravitz et al., 2000, p. 6). The authors argued that relative validity should suffice in an analytic study, where variations of one measure (e.g., teacher pedagogical belief) are associated with another teaching-related measure (e.g., instructional practices).

In a third example using survey methods, researchers in the USEIT study (Russell, O'Dwyer, Bebell, & Miranda, 2004) used scales from the TLC survey in the construction of a set of surveys to examine the relationships between pedagogical beliefs, instructional practices of teachers, and classroom technology use. Prior to survey distribution, the research team did extensive research and pre-testing of survey items, including gathering previous surveys, having reviewers provide feedback on the survey instruments, creating pilot surveys using at least 30 teachers and 20 students at 3 school levels, and receiving feedback from the respondents to clarify items. For the final instrument, seven items on pedagogical beliefs taken from the TLC study (Becker & Anderson, 1998) (also used in my survey) showed reliability estimates of .62 and .64 on two teacher measures created from the seven items. These reliability estimates are somewhat low, and could reflect a weakness in the consistency of the items, but it should be noted that these authors selected seven items of the thirteen that were used as an index in the TLC study. I drew from these previously published studies in designing the survey instrument for my dissertation.

If technology access and skill along with a constructivist-oriented teaching pedagogy influence students' use of technology in the classroom, it would be important to find out if regular public school teachers within the state of study follow this pattern. This would inform state educators of the importance of adequate computer access and assist them in developing technology training programs for teachers addressing both technology skills and constructivist teaching practices

CHAPTER III

METHODOLOGY

In this descriptive study, I used an online survey to gather both quantitative and qualitative data from a purposive sample of teachers in a Pacific Northwest state during the winter of 2009. I begin this section with a discussion of the survey instrument. Then, I describe the sampling plan, the data collection procedure, and the participants. Finally, I explain the variables of interest and discuss my approach to handling and analyzing the data.

The Survey Instrument

The survey instrument consisted of 45 questions, including 40 selected-response and 5 constructed-response questions (see Appendix A). In all, 13 questions addressed respondents' demographics, background, and school/classroom context, including access and availability to computers while 15 items were included from previous surveys designed to measure the beliefs and practices of teachers (Becker, Ravitz & Wong, 1999; Russell, O'Dwyer, Bebell, & Miranda, 2004). Of these 15 items, 8 used a six-point Likert scale that ranged from *strongly disagree* to *strongly agree*, and 4 items used a type of graphic rating scale with five fixed points, with statements anchoring opposite ends.

The anchors of the graphic scales represented a constructivist philosophy on one end and a didactic philosophy on the opposite end, with an unlabeled midpoint. For example, the text of one constructivist anchor read as follows: "I mainly see my role as a facilitator. I try to provide opportunities and resources for my students to discover or construct concepts for themselves." On the opposite end of this particular graphic scale, the didactic anchor text read as follows: "That's all nice, but students really won't learn the subject unless you go over the material in a structured way. It's my job to explain, to show students how to do the work, and to assign specific practice."

The remaining 3 items, of the 15 that measured beliefs, used a five-point Likert-type scale, with all points labeled and referencing two short vignettes. To illustrate, after reading vignettes that described both a didactic-type classroom discussion (Ms. Hill's class) and a constructivist-type classroom discussion (Mr. Jones' class), respondents could choose a preference as '*definitely* Ms. Hill's' (or definitely Mr. Jones'), or '*tend towards* Ms. Hill's' (or *tend towards* Mr. Jones') or choose '*undecided.*'

In all, 12 questions addressed frequency and type of technology use in the classroom, with a five-level scale ranging from *never* to *several times per week.* The choices for student technology uses (e.g., word processing, spreadsheets, presentations, etc.) were drawn from examples in previous studies, representing common classroom uses (Becker, Ravitz & Wong, 1999; Lowther et al., 2005; Russell, O'Dwyer, Bebell, & Miranda, 2004). The survey also included four constructed-response questions addressing the following topics: (a) technology proficiency and training, (b) software choices, (c) computer access, and (d) pedagogical changes relating to student technology use. Two questions were used to identify and track participants, and the final question was open-ended for general comments.

The final form of the survey was reviewed and approved by the Office of Human Subjects and my dissertation committee prior to administration. The survey was administered using an online survey tool with an estimated completion time of 20 minutes. The online format of data collection had the advantage of being economical, allowing a broad distribution, having an efficient data collection process, and being minimally intrusive to the participants.

In the spring of 2008, I tested the dependability and reliability of the online survey tool in a pilot study using pre-service and in-service teachers of various content areas ($n = 35$). I examined various online survey vendors and decided on the survey service that could display my questions appropriately and aggregate the data for analysis. For example, in the introduction to teaching philosophy there were two graphics that needed to be displayed to set up the didactic-constructivist dichotomy, and not all survey services display graphics. This process also allowed me to test the reliability of the survey company and the process of collection and retrieval of the data for analysis. I was able to test the ease of the site's navigability, the survey's readability, and the responses to open-ended questions, and, using feedback from the respondents, I made adjustments as needed.

The online format offered a degree of reliability in terms of the systematic administration of the survey. The survey format itself presented a clear layout and it was easy for respondents to use, with clickable selected-response answers. Consistency of scoring was assured through electronic tabulation of the results, which could be downloaded instantly without closing the survey. For the constructed-response questions, the text boxes allowed an unlimited length of response. Accuracy of recording teacher comments was assured through the process of downloading all responses verbatim.

Data Collection Procedure

Following a method for survey sampling described by Babbie (1990), I used a multistage sampling method to select a purposive sample of 7th and 8th grade mathematics teachers. In this method, a researcher identifies 'frames' within which to sample in each stage of participant recruitment. I used a list of middle schools (and their principals) as the sampling frame for the first stage and a list of teachers as the frame for the second stage. To contact all middle schools in the state, I obtained various lists of public schools, including the lists of locales from the *NCES Common Core of Data School Year 2005-06*, a middle school mailing list, a 2008-09 school directory, and a list of instructional technology resources (by school) from the state's Department of Education. I compared and culled the lists to create one master list containing only public middle schools in the state. Starting with the state's middle school mailing list, I added data for each school from the NCES and Department of Education lists and cross-checked the information with the 2008-09 school directory and the school websites.

This list of middle schools ($n = 258$) constituted the sampling frame for the first stage. Thirty-three schools were eliminated because the grade levels or the schools' organization were not clearly defined. Examples of schools I excluded were "schools within a school," which shared the same faculty, very small schools having mixed ages/grades that included 6th grade within the math curriculum, schools in which the contact person was unavailable, schools that were startups, or schools that had specialties in curriculum that did not lend themselves to a grade-level mathematics curriculum (e.g. at-risk program) In addition, one large district declined participation. Five of the largest districts required a formal application to conduct any research with school personnel, and in all five cases, approval was obtained. In all, 225 principals from 119 districts were contacted, and of those, 98 principals representing 80 districts agreed to participate.

I sent an e-mail message outlining the purpose of the study to the principals and superintendents of all the schools identified in the first stage of sampling (see Appendix B). In expectation of the challenge of getting enough principal and teacher participation, I did not limit participation by number of math classes taught (e.g., half-time, full-time, etc.). Especially in smaller or rural schools, teachers often have to teach different subjects and levels. The initial e-mail to the principal requested that the principal (or the office staff) provide the name(s) and e-mail(s) of the 7th and 8th grade mathematics teacher(s) in the school. In some cases, the principals forwarded my e-mail to teachers and told them to contact me directly if they were interested. In most cases, the names and e-mails were provided. If there was no response from a principal, I sent a reminder e-mail request after a two-week time period. If no reply was obtained, I made an additional effort to contact the principal by phone, which usually resulted in speaking to the principal, or leaving a message, and re-sending the initial invitations.

The teachers' names and e-mail addresses provided by the principals, together with the names of teachers who contacted me directly, became the second-stage sampling frame. The nature of this approval and volunteer process essentially created a sample of convenience from this second stage. I accepted all who were interested. I sent each teacher on the list an individually addressed e-mail that informed the teacher of the purpose of the study (see Appendix C). The e-mail included a hyperlink to the online survey and a copy of the informed consent. Participation in the survey was voluntary, and clicking on the link to start the survey was considered consent. Respondents were offered an incentive of a $5.00 gift card to Starbucks or Blockbuster to participate, along with the option to decline any gift.

If teachers did not respond to the first invitation, I sent two additional reminders approximately two weeks apart. For tracking purposes, I created a database of each school, district, school address, and contact information, and I entered the teachers' names and e-mail addresses into an electronic form associated with their schools. All contact and all e-mail correspondence with principals and teachers were documented. The difficulty of obtaining names and the process of follow up required that the survey remain open for three months. I mailed the gift cards to each respondent who completed the survey within one to two weeks of survey completion. The online survey subscription service, InstantSurvey, stored and tabulated the results for downloading into data analysis software. Respondents' anonymity was protected through an ID number assigned by the survey service. Schools or districts were not associated with any of the data. All data obtained were kept secure and shared with no one.

Participants' Description

Teacher names and e-mail addresses constituted the second stage list for participant recruitment. Of the 309 teachers who were contacted, 172 responded, a response rate of 55.7%. Respondents who started but did not complete the survey (n =14) were deleted from the sample. Table 1 displays the demographic details of the sample. The sample is comparable in most categories to the state's population of all middle school mathematics teachers, including years of teaching, age, and locale. The category in which the sample least resembled state demographics for this group was gender. Females comprised 64% of the sample, compared to their 57% proportion of the state's middle school mathematics teachers. Previous research has demonstrated that volunteers are more likely to be female (Meltzoff, 2004), and the difference of 7% is within the reasonable range for representativeness. Another area of slight difference was in the locales. The sample had 7% more suburban schools represented than the state's percentage of suburban schools and slightly lower percentages of rural and town schools than the respective state categories.

The geographic description of the sample was derived from the metro-central locale coding system of the United States Census Bureau (Phan & Glander, 2007). The Census Bureau's codes are assigned to schools based on their physical location, relative to the area's population, ranging from large city to rural, with two levels in each of four categories (creating 8 locale codes). To simplify the illustration of the geographic distribution for the sample, I used the four primary metro-centric locale categories of city, urban fringe (which I labeled suburban), town, and rural. For descriptive purposes, the two levels of each category were collapsed into one, while maintaining the city, suburban, town, and rural distinctions, resulting in four categories instead of eight.

The sample is fairly representative of public school 7th or 8th grade mathematics teachers in the state. Comparing the ages, experience, locale distribution, and gender, using Babbie's (1990) guidelines as a model, the sample also adequately represents variation that exists in the population as a whole.

Table 1

Demographics of Final Sample and Statewide Comparison

Category	Sample (n = 165)		Oregon (N = 763)	
Years Teaching	*n*	%	*N*	%
1	10	6	54	7
2 - 4	28	17	154	20
5 - 10	55	33	211	28
11 - 15	22	13	96	13
16 - 20	17	11	88	11
21+	33	20	160	21
Age				
20 - 30	31	19	141	19
31 - 40	46	28	212	28
41 - 50	46	28	191	25
51 - 60	35	21	187	24
61+	7	4	32	4
Gender				
Male	60	36	329	43
Female	105	64	434	57

Table 2 displays a comparison of the final sample to the first stage sampling population (N = 258).

Table 2

Demographics of Final Sample Compared to Recruitment Population

Category	Final Sample (*n* = 165)		Stage One Schools (*N* = 258)	
Locales	*n*	%	*N*	%
City	25	25	62	24
Suburban	36	37	76	30
Town	11	11	40	15
Rural	26	27	80	31

Variables of Interest

The variables of interest, as discussed in the previous chapters, are the predictor variables of *pedagogical beliefs*, self-rated *proficiency* using technology, self-reported *training* in technology use, number of *computers in the classroom and the computer lab*, and *availability of the computer lab*, and the outcome variables: (a) teacher-reported *frequency of technology use by students* and (b) teacher-reported *types of technology use by students*.

Predictor Variables

Predictor variables included pedagogical belief, proficiency using technology, training in technology use, number of computers in the classroom and the computer labs, and availability of the computer lab for classes.

Measuring pedagogical belief. To measure the continuous variable *pedagogical belief,* I summed responses to 13 items related to teaching philosophy on the survey instrument (see Appendix C, questions 15-19; 21-28). The construct validity of this index for pedagogical beliefs has been reported in previous studies. In the TLC study, these 13 items were identified in an exploratory factor analysis (tested for reliability, with a reliability coefficient of .83) as an indication of a construct that contrasted constructivist teaching practices and didactic teaching practices (Ravitz, Becker & Wong, 2000). Thus, these same items were treated as a unidimensional instrument in my study. In a subsequent section, I include the reliability estimates and individual values of item-total correlations.

To correctly score and sum the 13 items of the index, I first reverse-scored 8 of the questions because of the wording and scoring of the questions. On some questions, a low score would appropriately indicate a didactic philosophy and a high score a constructivist philosophy. For example, on the following question: "Students should help establish criteria on which their work will be assessed," *strongly disagree* = 1, and *strongly agree* = 6. On other questions, the same scoring applied to the response choices would not accurately reflect the constructivist philosophy, unless reverse-scored. For example, on the following question: "Instruction should be built around problems with clear, correct answers and around ideas that most students can grasp quickly," a teacher having constructivist philosophy would 'strongly disagree'. If that response were scored with a value of 1, it would not indicate a constructivist philosophy. Recoding these reverse-scored items resulted in the higher score consistently indicating a constructivist pedagogy. This re-coding and summing of responses resulted in a single score for each respondent on a continuous scale, ranging from 13 - 72. A low score indicated teachers who held didactic beliefs, and a high score indicated those who held constructivist beliefs.

Measuring teacher reports of proficiency using technology. Teachers self-reported their proficiency using technology in the classroom through their response to a single item on the survey. This item, which asked teachers to rate their current level of technology proficiency, provided the following response options: (a) *beginner*, (b) *novice*, (c) *intermediate*, and (d) *expert*.

Measuring training in technology use. In addition to reporting their proficiency using technology, teachers responded to a question about how much professional development training in technology they had received since they had started teaching. Scores for this variable were derived from the following categories: (a) *none*, (b) *very little,* (c) *moderate* amount, (d) *quite a bit*, and (e) *extensive*, with *none* assigned a value of 1, and *extensive* a value of 5. The correlation between the variables of *proficiency in using technology* and *training in technology use* was $r = .26, p < .01$.

Measuring access to technology in the classroom. One item on the survey asked teachers to identify how many computers students had access to in their classroom. Responses to this item were coded 1 to 9, representing *none* to a 1-1 student to computer ratio, respectively, and these scores were used as an indication of teachers' access to technology for classroom use. The following choices were provided: (a) none, (b) 1-2, (c) 3-4, (d) 5-6, (e) 7-10, (f) 11-15, (g) 15-20, (h) 20+, and (i) 1-1 ratio. Another part of the survey asked about teachers' access to computers in a computer lab. Responses to this item were coded the same way as responses to the question about access to technology in the classroom, resulting in a range of responses from 1 to 9.

Measuring availability to the computer lab. In addition to teachers reporting the existence of a computer lab, and the number of computers in those labs, one survey item asked teachers to indicate the availability of the computer labs for their classes. This item included the following response choices: (a) never, (b) rarely, (c) usually, and (d) always.

Outcome Variables

I examined two outcome variables: frequency of technology use by students and types of technology use by students.

Frequency of technology use by students. Using responses to another section of the survey, I created a continuous variable to measure frequency of in-school student technology use, as reported by mathematics teachers. The items are listed in the following paragraph, covering types of technology use. Each item in this section of the survey had the following response choices: (a) *never*, (b*) 1-2 times/year*, (c) *several times/year*, (d) *several times/month*, and (e) *several times per week*. Responses on each item were scored from 1-5 (1 = *never*; 5 = *several times per week*) and then added together, creating a total *frequency of use* score for each respondent. A low total score represented low frequency of use, and a high total score represented a high frequency of use, with a possible range of 12 – 60.

Types of technology use by students. Similarly, I used responses from the frequency of technology use section of the survey to measure teachers' reports of the types of technology their students used in the classroom. I identified the most common classroom uses found in previous studies (Becker, Ravitz & Wong, 1999; Lowther et al., 2005; Russell, O'Dwyer, Bebell & Miranda, 2004) and established the following categories: (a) drill and practice, (b) integrated learning system, (c) word processing, (d) spreadsheets, (e) databases, (f) presentation tools, (g) graphics/visualization tools, (h) graphing calculator/PDA, (i) E-communications, (j) online research, (k) simulations, and (l) problem solving with real-world data. Teachers had the option of indicating how often they had students use this type of technology in the classroom. Responses of *never* were coded '0'; all other responses were coded '1', and the resulting values were summed to arrive at a total *type of use* score for each respondent. A low total score indicated few types of use, and a high score indicated numerous types of use. Possible scores for this variable ranged from 0-12.

Quantitative Data Preparation

After the online survey was closed, I downloaded the data from the online survey service and "cleaned" the data for analysis. I deleted seven incomplete surveys so the resulting data set contained only responses where the teacher had answered every question on the survey.

For the items included in the predictor variable of teacher pedagogical beliefs, I computed two internal consistency of reliability estimates, Cronbach's alpha ($r = .84$) and a split-half estimate, Spearman-Brown corrected correlation ($r = .87$). For the split-half estimate, I chose selections from the different sections of the survey, so that each half had the same type of question, although one half had seven items, and the other half had six items. In addition, I calculated the item-total correlations for each of the 13 items from this section of the survey (see Table 3).

Table 3

Item-Total Correlations Pedagogical Belief Items to Belief Index

Item Text	Correlation
Discussion students would gain more useful *skills*	.63**
Discussion students would gain more *knowledge*	.66**
Student *interest* vs textbook coverage	.51**
Sense-making vs curriculum coverage	.58**
Multiple *activities* vs whole class assignments	.63**
Facilitator vs explainer	.74**
Students should help establish *criteria* for assessment	.54**
Freedom to move around promotes student *initiative*	.54**
Teacher should decide the activities	.47**
Teachers know more than students	.58**
Quiet classrooms are needed for learning	.57**
Problems should have *clear correct answers*/ideas	.56**
Learning depends on *background knowledge* and learning facts	.66**

$^{**}p < .01$

Treatment of Qualitative Data

I collected the qualitative data concurrently with the quantitative data, in the form of 5 constructed-response questions interspersed within the survey instrument (see Appendix A). The purpose of the qualitative data was to provide additional sources of data related to teacher use of technology and pedagogical beliefs and to add context and teacher "voice" to the quantitative responses. The questions addressed the following areas: (a) teachers' technology training and perceived proficiency with technology (b) teachers' choices of software, (c) teachers' strategies to gain access to technology, (d) changes in teacher pedagogy, and (e) open comments. I downloaded the responses in their entirety from the survey service and entered them into tables in a word processing program. I then coded the responses for each question and counted the frequencies of each theme, and entered the results into a spreadsheet (Creswell & Plano Clark, 2007).

In the treatment of open-ended questions, internal validity in qualitative analysis calls for credibility, trustworthiness, and accuracy (Miles & Huberman, 1994). In this study, the answers to open-ended questions were recorded digitally by the online survey, so accuracy and credibility were assured because the comments were entered directly by the respondents. In the transformation of the data, coding and themes were established for the primary question relating to pedagogical beliefs and change in instructional practice (see Appendix A, question #42) after consultation with two university professors who had experience in qualitative research. I explained the overall purpose of the study to these reviewers as well as the intent of the questions and then provided them with the codes I used during analysis of the qualitative data. The code checkers read the answers and applied codes separately. We later had a session to discuss discrepancies and strengths of the coding approach and reached agreement on the coding system and findings. In reading through the qualitative data, all reviewers looked for disconfirming evidence as well as confirming evidence, a practice that helps to establish the data as a representation of "real life" (Creswell & Plano Clark, 2007)

CHAPTER IV

RESULTS

In the following section I present and discuss the survey results, addressing the quantitative data first and the qualitative data second. I begin by presenting demographic information and descriptive statistics, then I report the results of my regression analysis, ending with results of the constructed-response items from the survey.

Demographics

In all, 165 teachers of 7th and 8th grade mathematics provided responses to all survey items used in my study. None of the teachers in my sample rated themselves as having a *beginning* level of proficiency. Nineteen of the teachers (11%) reported themselves as *novices* with the use of technology for teaching mathematics. Fully 125 teachers (76%) rated themselves as *intermediate*, and 21 (13%) rated themselves as *expert*. In terms of professional development training in technology, 5 (3%) of the teachers reported having participated in *none*, 55 (33%) indicated that they had participated in *very little,* 71 (43%) reported having participated in a *moderate amount,* 24 (15%) indicated they had done *quite a bit* of professional development, and 10 (6%) indicated they had engaged in *extensive* professional development.

Slightly more than half of the teachers (n = 96, 58%) indicated that they had *no* computers in their classrooms for students' use, with another 48 (29%) reporting having *1 to 2*. Only six teachers (4%) and two teachers (1%) reported having *3 to 4* or *5 to 6* computers in their classrooms, respectively. Only three teachers reported having more than seven computers in their classrooms. When asked about the number of computers in computer labs, only 5 of the teachers (3%) indicated that they had *no* computer labs. No teachers reported having ten or fewer computers in the lab. Two teachers (1%) reported having *11 to 15* computers in the lab. Ten teachers (6%) reported having *15 to 20* computers in the lab. Seventy-two teachers (44%) reported having *20+* computers in the lab. Seventy-six teachers (46%) indicated that they had *a 1:1 student to computer* ratio in the computer lab. In responding to the question on availability of the computer lab, 18 teachers (11%) reported that the computer lab was *never* available, 76 (46%) indicated that the lab was *rarely* available, 65 (39%) reported that the lab was *usually* available, and 6 (4%) teachers indicated that the computer lab was *always* available for their students to use.

In addition to the questions about access to computers and technology in their classrooms and through school computer labs, teachers were asked about the type of technology they used and how often they used each type. Table 4 presents frequency counts of responses to these questions in percentages.

Table 4

Percentages of Frequency and Types of Technology Use

Types of Use	Never	1-2 times/ year	Several times/ year	Several times/ month	Several times/ week
Drill and practice	30	20	25	12	13
Integrated learning system	46	17	10	12	15
Word-processing	45	17	22	8	8
Spreadsheets	46	30	19	4	1
Databases	61	24	11	3	1
Presentation	32	18	20	13	17
Graphics/visualization	38	18	21	9	13
Graphing calculator/PDA	39	12	20	8	21
E-communications	55	10	12	10	13
Online research	34	32	20	8	5
Simulations	43	20	25	9	3
Solve problems using real-world situations/data	25	30	23	13	9

Note: Values in table are percentages of answers on row item

Descriptive Statistics

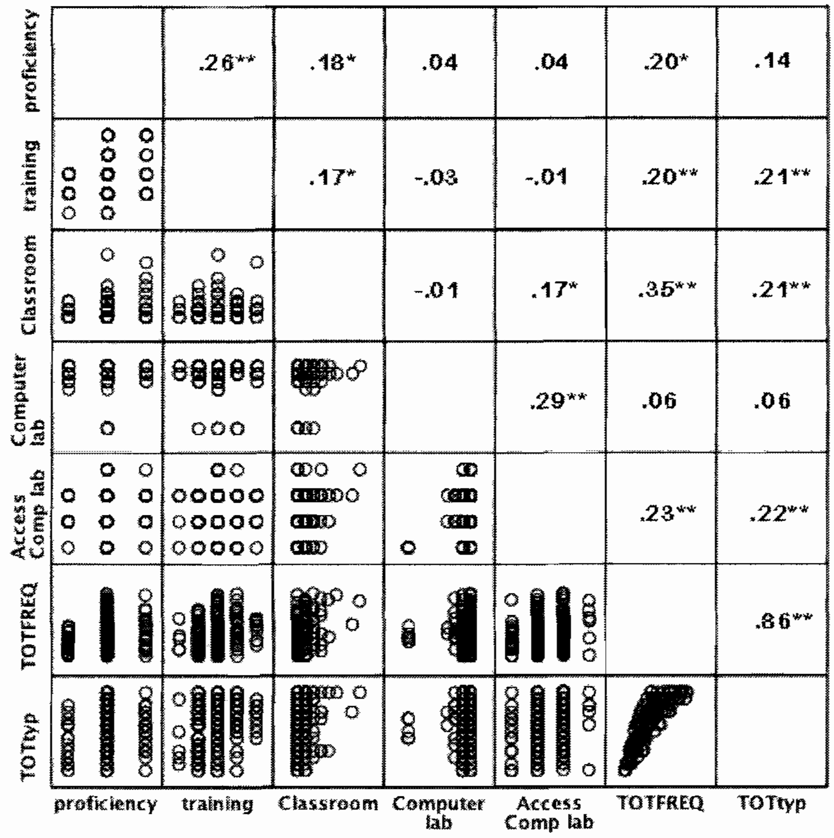
Table 5 presents descriptive statistics for respondents' pedagogical beliefs as well as their self-reported frequency of classroom technology use and type of technology used in the classroom. The score for pedagogical beliefs was calculated by summing responses to the 13-items on the survey previously validated by Ravitz et al. (2000) and Russell et al. (2004) as a measure of teachers' constructivist pedagogical beliefs. The range of possible scores on the pedagogical belief index was from 13-72. Information about frequency of use was derived from summing the frequency rating scores of 12 items listed as types of use such as drill and practice, word processing, spreadsheets and presentations. For frequency of use, the lowest score possible was 12, and the highest possible score was 60. Data for type of use came from adding the total number of technology uses from the list of 12 items just mentioned, with the range of possible scores from 0-12.

Table 5

Descriptive Statistics

	n	*M*	*SD*	Minimum	Maximum
Pedagogical Beliefs	165	47.2	8.28	24	69
Frequency of Use	165	26.87	9.52	12	52
Type of Use	165	6.98	3.49	0	12

Figure 1 presents the scatterplot and correlations of the five predictor variables, proficiency, training, class computers, lab computers, and availability of computer lab, and the two outcome variables, total frequency of use, and total type of use. In the results presented, the relationship between proficiency and training shows a small but significant correlation ($r = .26, p < .01$). Seven correlations involving the variables of proficiency, training, computers in class, and access to computer labs, and the two outcome variables of frequency of use and type of use were statistically significant and in the small to moderate range. The correlation between classroom computers and frequency of use was the highest of those seven correlations, but moderate at .35. The correlation between total frequency and total type ($r = .89$) can be disregarded because these two variables are collinear and are analyzed as separate outcomes.



$*p < .05$; $**p < .01$

Figure 1
Scatterplots and Correlations of Predictor and Outcome Variables

Regression Analyses

Based on my synthesis of prior research related to teacher use of technology with students, I identified six potential predictor variables to test in a regression analysis: pedagogical beliefs, proficiency with technology, training in the use of technology in the classroom, number of computers available in the classroom and in computer labs, and the availability of computer labs for students. The essential analysis question is: How well does pedagogical beliefs predict frequency and type of use of technology by students?

First, I address the assumptions about the variables used in the multivariate regression analyses. Then, I present the results for the regression analyses predicting frequency of technology use, followed by the results for the regression analyses predicting type of technology use.

I tested for the reliability of the predictor variable of teacher pedagogical beliefs by computing two internal consistency of reliability estimates, Cronbach's alpha ($r = .84$) and a split-half estimate, Spearman-Brown corrected correlation ($r = .87$). For the split-half estimate, I alternated choices of questions from three sections of the survey to approximate equal halves, although with 13 items, one half had 7 items and one half had 6 items.

To explore the distribution for the variables used in the model, I used P-P plots to investigate normality. "The P-P plot plots a variable's cumulative proportions against the cumulative proportions of the test distribution" (Garson, 2009). Conformity of the plot to a straight line is an indication of the distribution's normality. Most of the variables in Figure 2 reflect fairly normal distributions, except for "Classroom" (computers) in the bottom left. Upcoming analysis will explore the results of assumptions for multiple regression in regard to use of these variables for the model fitted.

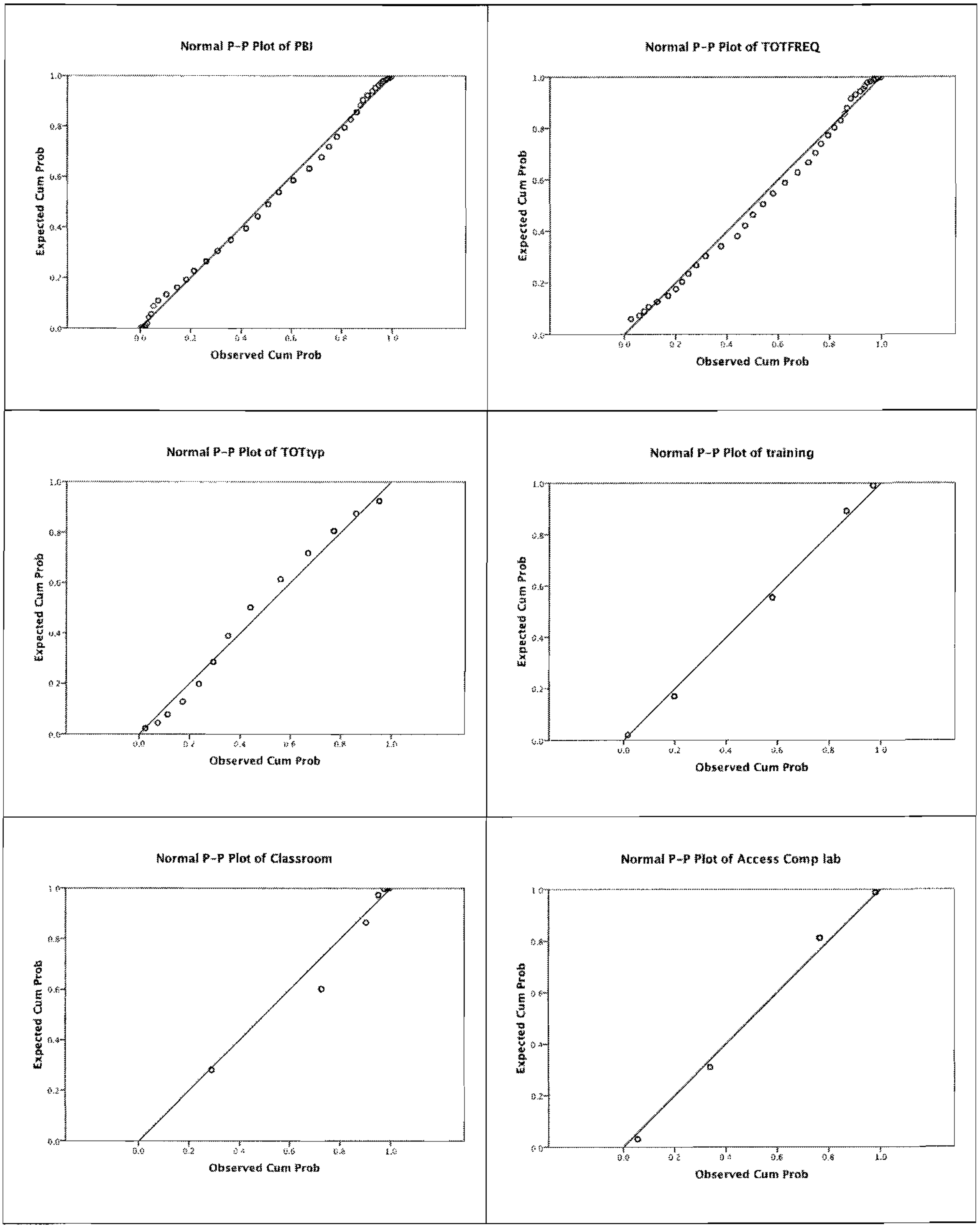


Figure 2

P-Plots Exploring Normality of Six Original Variables

Results of Regression Analysis Predicting Frequency of Use

Table 6 presents the results of my regression analyses predicting frequency of use. I used multivariate regression analysis to create three models, using variables previously identified in the literature as potentially significant in increasing teachers' use of technology with students and then adding the pedagogical belief index model.

The analytic question to be addressed here is how well does pedagogical belief predict teacher use of technology, after controlling for proficiency, training and the three variables of computer access?

To control for the five variables, they were entered as a block, to be called here Model 1. The first model significantly predicted the frequency of use, $F(5, 159) = 7.16$, $p < .001$. Model 1 explained 18.4% of the variance in frequency of use, but only class computers and availability of the computer lab were significant predictors. The variable of training approached significance ($p = .08$). The regression equation for Model 1 is as follows: Frequency of Use = 1.99 Proficiency + 1.35 Training + 2.20 Class Computers + .07 Lab Computers + 2.35 Lab Availability + 6.54.

In the second model, I dropped the variables proficiency and computer labs, since they were not necessary to control, and added the primary variable of interest, pedagogical beliefs, to explore whether it added predictive purpose to the model. Model 2 was significant, $F(4, 160) = 9.21$, $p < .001$, but the variance explained remained virtually identical to Model 1 at 18.7%. Therefore, pedagogical beliefs is not considered a predictor variable useful after controlling for the other variables in Model 1. The regression equation for Model 2 is as follows: Frequency of Use = 1.67 Training + 2.21 Class Computers + 2.32 Lab Availability + .13 Pedagogical Beliefs + 6.54.

After I determined that pedagogical beliefs made no significant contribution to Model 2, I ran a third model without it. Model 3, which is my final model for this research question on use, includes only training, class computers, and availability to the computer lab. The model was significant, $F(3,161) = 11.28, p < .001$. This final model explained 17.4% of the variance in frequency of technology use by students. The regression equation for Model 3 is as follows: Frequency of Use = 1.60 Training + 2.31 Class Computers + 2.41 Lab Availability + 12.65. Students of teachers who had more training and greater access to computers used technology more frequently.

Table 6

Relationship of Pedagogical Beliefs, Proficiency, Training and Computers to Frequency of Use

Variable	Model 1	Model 2	Model 3
Proficiency	1.99		
Training	1.35	1.67*	1.60*
Computers in class	2.20**	2.21**	2.31**
Computers in lab	0.07		
Lab Availability	2.35*	2.32*	2.41*
Pedagogical Beliefs		0.13	
Constant	7.16	6.54	12.65
R Square	18.40	18.70	17.4

*$p < .05$; **$p < .01$

Results of Regression Analysis Predicting Type of Use

The analytic question to be addressed here is similar to that above, but addresses types of technology as the outcome variable. The analytic consideration to be considered is how well does pedagogical belief predict types of technology used, after controlling for proficiency, training and the three elements of computer access? Table 7 presents the results of my regression analyses predicting type of technology use.

Similar to the prior analyses, I created three models, using the five variables as predictors of increased teacher variety of technology use. The first model, using proficiency, training, computers in class and the lab, and availability of the lab, was significant, $F(5, 159) = 4.23, p < .01$. Model 1 accounted for 11.7% of the variance in type of use, with training and availability of the computer lab being significant predictors. Classroom computers approached significance ($p = .08$). The regression equation for Model 1 is as follows: Type of Use = .45 Proficiency + .67 Training + .40 Class Computers + .02 Lab Computers + .93 Lab Availability + .65.

In Model 2, I eliminated the non-significant variables of proficiency and computer lab, and added pedagogical beliefs. The model was significant, $F(4, 160) = 5.94, p < .01$. Model 2 explained 13% of the variance in type of use, with training and availability of the computer lab remaining significant. Pedagogical beliefs ($p = .09$) and classroom computers ($p = .08$) approached significance. The regression equation for Model 2 is as follows: Type of Use = .75 Training + .39 Class Computers + .91 Lab Availability + .05 Pedagogical Beliefs – .49.

Removing pedagogical beliefs and classroom computers left two predictors, training and lab availability to include in Model 3, which was significant, $F(2, 162) = 8.40, p <.001$. Model 3 explained 9.4% of the variance in types of technology used. The regression equation for Model 3 is as follows: Type of Use = .82 Training + 1.07 Lab Availability + 2.10. The more training and computer lab access teachers had, the more types of technology their students used, although teachers' pedagogical beliefs were not a contributing factor.

Table 7

Relationship of Pedagogical Beliefs, Proficiency, Training and Computers to Type of Use

Variable	Model 1	Model 2	Model 3
Proficiency	0.45		
Training	0.67*	0.75*	.82**
Computers in class	0.40	0.38	
Computers in lab	0.02		
Lab availability	0.93*	0.91*	1.06**
PBI		0.05	
Constant	.65	-.49	2.10
R Square	.12	.13	.09

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

Testing Assumptions of Multiple Regression

I tested for the assumptions of normality, linearity, homoscedasticity, using the variables of Model 3 for frequency of use and the variables of Model 3 for type of use to establish trustworthiness in the results (Osborne & Waters, 2002). Figure 3 displays the results of testing the assumptions for the dependent variable frequency of use. The P-Plot for frequency of use indicates a normal distribution for the residuals. To test linearity, the scatterplot “should show a random pattern when nonlinearity is absent” (Garson, 2009). In Figure 3, no evidence suggests non-linearity, or that a curvilinear relationship is present. The assumption of homoscedasticity can also be tested by observing the scatterplot in Figure 3. Homoscedasticity would be violated if the variance of error is not constant, for example, showing a fan-shape or bowtie pattern (Osborne & Waters, 2002). For the dependent variable of frequency of use, homoscedasticity is assumed.

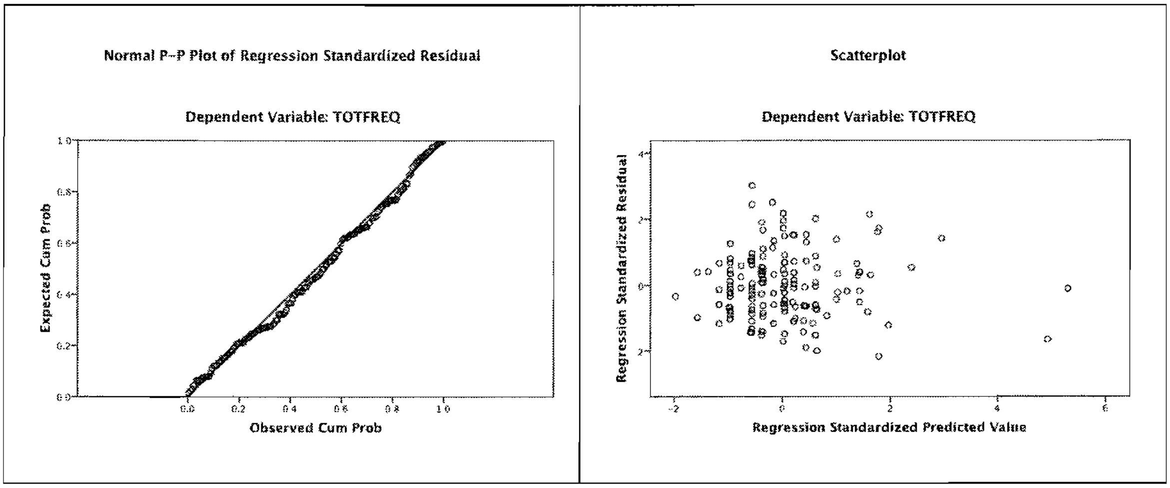


Figure 3

Plots for Assumption of Normality, Linearity, and Homoscedasticity for Frequency of Use

Figure 4 displays the plots for testing the assumptions for the dependent variable type of use. The P-Plot shows slight deviation from the line in the middle to upper range, but indicates a normal distribution of the residuals. In the scatterplot, the assumption of linearity is not violated, but a narrowing pattern is evident at both ends of the scatterplot, which indicates a slight amount of heteroscedasticity and a potential violation of this assumption. I conducted the Goldfield-Quandt test, which addresses the type of fan shaped pattern displayed, and it met the assumption of homoscedasticity.

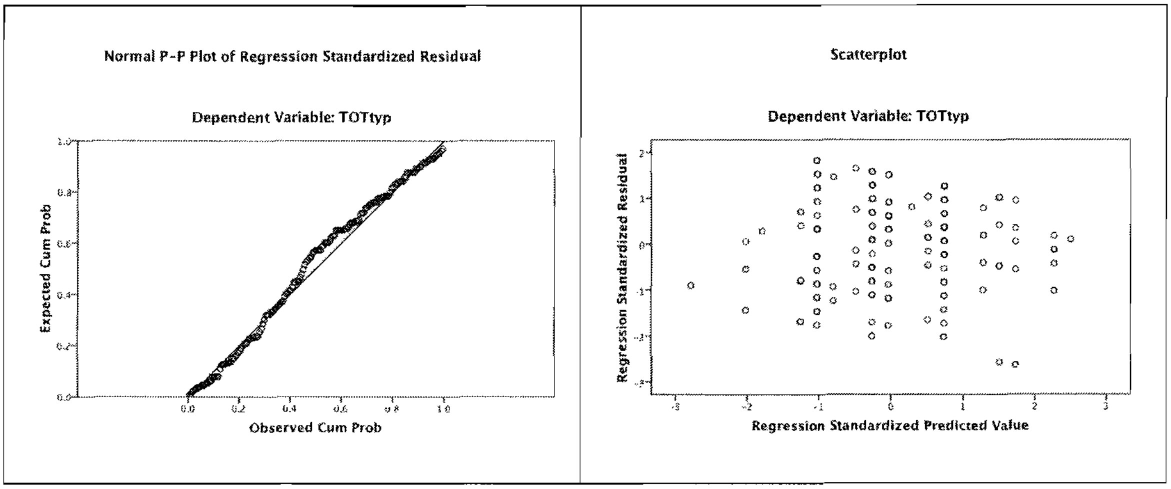


Figure 4

Plots for Assumption of Normality, Linearity, and Homoscedasticity for Type of Use

Correlations between Pedagogical Beliefs Index and Specific Types of Use

I explored the correlations of the pedagogical beliefs index to each type of use. The pedagogical beliefs index was correlated significantly with two types of use: drill and practice and e-communications, but both correlations were small. The first correlation was negative ($r = -.19, p < .05$), meaning the more constructivist teacher would use less drill and practice as a student activity. In contrast, the second correlation was positive, ($r = .27, p < .01$), meaning the more constructivist teacher would use more e-communication activities with their students. In my survey, e-communications were described as “video, audio, data, online”.

Qualitative Data Results

I included five constructed-response questions in the survey to add additional depth to the quantitative results. In the following section, I summarize responses from three of those questions and provide illustrative quotes. Those questions addressed the following topics: (a) teachers' background, experience, and training in technology, (b) instructional changes due to student technology use, and (c) resolving issues of computer availability and access.

Teachers' Background, Experience, and Training in Technology

Survey respondents reported feeling prepared almost equally by their college coursework and supplemental classes, their own initiative (self-taught), and targeted trainings and workshops. Less frequently mentioned, but still notable, was technology experience gained from a job prior to teaching. Table 8 provides frequency counts for responses to the survey question related to where teachers had received training on using technology in the classroom.

Table 7

Background, Experience, and Training to Integrate Technology

College/ Courses	Self-Taught	Trainings/ Workshops	Prior Career	No Comment/ Not Used	Mentioned Obstacles/Limits
59	57	53	23	16	6

Note: Values are number of times mentioned

The importance of college courses. Teachers mentioned their college years or supplementary courses most frequently (59 times) as an important preparatory factor for technology integration. Many reported having completed a computer science minor or taken courses in computer science as part of a mathematics degree. Teachers mentioned having completed courses in technology as part of their teacher education program or stand-alone courses for professional development or mathematics training after being licensed.

> While doing undergraduate studies, I obtained a Minor in Computer Science, and through it learned how networks, databases, computer systems are built and work. I also used computers quite a bit for word processing, spreadsheets, and other computer programs specific to math.

> My undergraduate degree is in engineering. I enjoy learning about technology and welcome the chance to increase its use in my classroom.

> During college I have taken several technology classes for web design and lesson integration. Recently I finished a class on Smart Board that has allowed me to broaden my teaching styles.

> Two terms of required technology courses as part of my education program, along with technology related instruction in several mathematics courses. This would include learning Geometer's Sketchpad and statistics software.

The impact of self-taught experiences. The second strongest theme to emerge from these responses, mentioned 57 times, was that teachers had taught themselves how to use technology. Many of the comments indicated that they had used technology for many years, even from the earliest days of personal computers, and just kept learning as technology progressed. The hint of self-reliance was also evident.

> I first used a computer for school when I was in 6th grade. Ever since then I have been interested in integrating computers and technology into my work as a student and as a teacher. All of my training for using technology in the classroom has come through personal experience and experimentation.

> I started using technology with Apple 2e's. I have used computers since, and have also been using graphing calculators since 1992, interactive white boards since 2003, personal response devices (clickers) since 2007.

> I learned by trial and error, teaching myself and asking my peers in the building I am at. Realizing technology is important to all I have tried to incorporate as much as I can.

> I am just a computer nerd, and I love scrounging around the internet to find useful stuff. I have a SMART board and a Document Camera in my room and I

> consistently try to figure out new ways to use them and make things interesting for the kids.

Independent trainings and workshops. Teachers mentioned the availability of frequent and varied trainings and workshops as having a positive effect on their technology proficiency, accounting for 25% of the responses. The trainings and workshops came in different forms, sometimes offered as in-services, specialty training offered by vendors, conferences workshops, summer sessions, and grant-related trainings. Numerous comments referred to trainings that were offered, but because the teachers did not have the appropriate equipment to apply the training, they chose not to attend.

> I've had 4 years of extensive training using document cameras, laptops, projectors and clickers in the classroom. Math teachers are also chosen to attend Regional and National level computer conferences to keep up with the latest in Technology. Our district also offers several classes every year on various ways how technology can be integrated into our math classes. On top of that each building has someone who is given the extra time to help out classroom teachers with any problems or trainings they might have.

> I have taken several SMARTboard training classes offered by the district and this has helped the most because I get the training on the actual technological device that I will use in the class.

> I was chosen to participate in a technology grant. This grant placed many pieces of technology in my classroom and also included a fair amount of training on how to use the different equipment and how to implement it into a math classroom.

> I was not very proficient with technology before I started teaching. But I have been to quite a few trainings and have become much more efficient since becoming a teacher.

The lasting impact of a prior career. A fair number of respondents mentioned their experience in previous careers as evidence of their preparation to integrate technology. Much of their experience was at very high levels, especially compared to the level that they were teaching at the time they completed the survey. For this group, their confidence in their own proficiency was quite apparent.

> I have training as an economist - which required mathematical models and quite a bit of statistical programming. This prepared me and opened my mind to ways mathematics can be both demonstrated and incorporated into the curriculum using computers. I also was aware of the importance and efficiency of being able to do such things as analyze data on basic programs such as excel. Honestly I cannot imagine doing high-level math problems or presenting mathematical results without technology.

> I was a research chemist for 8+ years. We used many different types of technology, including servicing our own lab equipment. Many different software packages were used for the analysis and presentation of data.

> After teaching for a year at the college level, I began working for a Fortune 500 company in the IT/Process Control Department. I was a programmer for 7 years and well as a mathematician that used programming to help employees interpret production data.

Lack of equipment and access as a barrier. Unprompted responses emerged from this question in the form of lack of resources. Twenty-five teachers offered their views that they have adequate proficiency and motivation to use technology, and even see it as a necessary part of their students' education, but the equipment and/or its availability was lacking.

> I currently use a document camera. I feel that I've learned the most about technology through trying things and hoping it worked. I've never been afraid of technology, but we have had limited access to it in our school.

> I ended my college career with a minor in computer science. I have since taken several workshops for integrating technology into the classroom. I am very

> prepared to integrate technology into my classroom. However, I have not because we do not have enough computers to do so.

> Our school district has done an admirable job of making updated training available to us, but our hardware, software, and internet access capabilities have degraded to the point of making the use of technology in the classroom, or the computer lab, a painful experience.

> I've always been relatively technologically savvy and had jobs prior to teaching that required me to be computer literate in several areas of software use... I would integrate technology much, much more often if my school had the hardware, software, space, and class time to use it.

Instructional Changes Due to Student Technology Use

One of the questions on the survey asked teachers, "If applicable, in what ways has student use of technology changed your instructional philosophy?" Half of the respondents reported "no change," "not applicable," or chose not to answer. However, four themes emerged from those who responded: student technology use led to more constructivist pedagogy, student technology use enhanced didactic pedagogy, teachers expressed reservations about the emphasis on technology, and teachers commented on obstacles to using technology in the classroom.

Technology use prompting a shift to more constructivist pedagogy. As noted in the literature synthesis, constructivist teachers tend to promote student-directed learning (with less teacher-directed activities), allow students to develop questions and interests to motivate themselves, encourage higher-level learning, and allow students to participate in multiple activities at different levels of difficulty within a single classroom grouping. Many of these indications of constructivist pedagogy can be noted in teachers' responses to this question.

In the following comment, the flexibility of the technology tools and the role of the teacher to determine its use is evident. Some students explore and learn in multiple ways, and some use the tools in a "mechanized" way. This teacher reveals a constructivist inclination in tapping technology's potential:

> There's a much greater opportunity for interactive and multi-style learning, and for exploring ideas that are triggered by classroom activities. Many students take advantage of those tools to expand their knowledge and understanding. Many just use it as a typing machine and a mechanized research tool for very basic information. Leading them to see beyond that is the tricky part.

In the following comments, teachers challenge the notion of "right answers" and the teacher being "the dispenser of knowledge." Students' self-directed learning is emphasized.

> I find that technology allows me to remove myself from being in the way of their learning; instead of me being the all-knowing dispenser of knowledge, I am the

> guy who asks the questions that allow them to find their own learning. They become personally responsible for their growth, or lack of it.

> Technology has helped me to see that it is important to teach kids how to self-learn. If they learn how to locate information, find answers and teach themselves from the information they find, then their potential is limitless. Being able to do this empowers them and causes them to challenge and question what is "the right answer" in many contexts. I do still believe that within this environment of self-learning, it is necessary to provide some direction and foundational information and skills development to use as a springboard for continued thought and exploration, otherwise they will not have a starting point.

Teachers' self-reported shift to student-directed work (empowerment), higher-level thinking, and multiple activities taking place concurrently in the classroom is displayed in the following comments:

> There has been an influx of higher thinking order skills using the technology, and student learning is definitely more student-directed than before. Also, I think that I enjoy the creation aspect and watching the students empower themselves to be the responsible entity for their own work

> I do not do near as much teacher-directed instruction and as a class we are more able to create vast amounts of information instead of everyone working on the same thing.

Technology use enhanced didactic pedagogy. Compared to the teachers who mentioned technology use as having a constructivist influence, others emphasized didactic uses of technology, where the teacher uses it as a tool to enhance lectures or teacher-led demonstrations.

> I am now able to project real and current examples of my subject, mathematics, easily as needed.

> I try to incorporate something most days from the Internet, kids like it, I like it, and it is relevant. You Tube has become a fabulous resource for educational lessons.

The following comments reveal more didactic uses of technology by students, the first for testing practice and the other for support of material previously learned.

> I use it to help learn how to take test on a computer. State tests are now given only on the computer so the students need to learn how to take a computerized multiple choice test.

> I believe all students need to know how to do math with and without technology. The technology enhances the learning they have already had.

Teacher reservations about technology use. For some teachers, this question provided an opportunity to express their concern with the trend toward technology use by students and offers some disconfirming evidence that technology use changes their philosophy or the classroom environment for the better.

> Technology and the Internet are wonderful tools in moderation. However, the scope and breadth of students' imagination and inventiveness has dramatically decreased. With multi-media offering so much stimulation and over-abundance of information, it is getting more and more difficult for young people to carve out a space for creating and independently challenging themselves without relying on a machine.

> I think it's important not to become too reliant on it, and expect that it can reach the "heart" of a student. It can allow some students to express themselves in a better way, but it's become more apparent to me this year that some (many?) students are also already bored with technology.

Challenges with accessing technology resources. Another group of teachers were not disapproving of technology use but felt the obstacles to its use were insurmountable. The first comment addresses logistics, the second, support (perhaps in available resources).

> I believe that technology does have a place in math curriculum, but getting it approved, bought, downloaded into the computers, then finding the time to integrate that into the curriculum (while jostling with the other teachers to get into a lab) would make it virtually impossible to use. I think it could be beneficial, but until it becomes a little closer to actually becoming a reality, I don't know how it will change my instructional philosophy in the future.
>
> [my teaching philosophy is..] Much more interactive and student-directed, but the availability of computers in the school is problematic. I am extremely enthusiastic about using technology, but saddened (and not surprised) by the lack of support for using this.

Resolving Issues of Computer Availability and Access

This question on the survey asked, “Please comment how you resolve issues of computer availability and access for your students.” The intention of this question was to understand how teachers overcame barriers to technology use, and to perhaps discover strategies or motivations used by the highest technology-using teachers. Of the three most frequent responses, two were distinctly related to access difficulties, and the third most frequent response was that it wasn't a problem, due to adequate resources or planning.

Computer lab is booked for testing. Nearly a third of the respondents (31%) mentioned that the lab was booked for testing, obstructing their plans for using the computer lab; some expressed resignation and frustration and hoped for a bit of luck.

> We just don't get our hopes up to do technology projects/activities. Our labs are used for State Testing, and so they are booked for a good portion of the year. Then it's just first come first serve. If you happen to want to do something during a period that there aren't many tech minded people, then there's a good chance you'll get a slot.

> The testing and the district reading test take up most of the computers available in the school. I only have one computer in my classroom and limited time (maybe once a month if lucky) to use the computer lab. I used to use Geometer's Sketchpad but don't have the computer time available to me anymore.

> I can only go to the computer lab before winter break because both labs are booked daily for testing after that! It's very frustrating!

General challenges of access, faulty equipment, or competition. Of those that responded, 11% mentioned that beyond testing, computer equipment doesn't always work or other teachers compete for the resources, circumstances which obstructed use.

> The only time our labs can be used is when we are not testing - which is about 2 months out of the school year - and then we need to schedule class period usage (becomes difficult when there are 30 teachers fighting for time).

> I can never guarantee that computers will be available, and even if they are, there aren't usually enough for all the students and half don't work, so it always seems to be more work than it's worth. How do I resolve that issue? I generally don't use them!

Adequate resources and good planning. Nearly 14% of the respondents felt that there was no access problem at their school because adequate resources were available with labs or laptop carts. Another 11% of respondents appeared to be proactive teachers who used advance planning and scheduling to meet their needs.

> I schedule the computer lab far ahead of time and plan to take my classes in for specific projects. I have enough graphing calculators in my classroom for all students.

> I communicate with other teachers in my building to find computer access times for my students. If I cannot access enough computers for a 1-1 ratio of student to computers, I will place students in groups and assign each group to a single computer.

If availability is a problem, I use the SmartBoard to have the whole class work on something without the need for 1-1 computer access.

CHAPTER V

DISCUSSION

In this section I first present a summary of findings from this study. I then describe the limitations (threats to validity). Next, I provide an explanation of my findings in relation to the literature and my introductory statements. Finally, I suggest opportunities for future research.

Summary of Findings

The pedagogical beliefs index was not a predictor of technology use in middle school mathematics classes. The findings suggest that teacher training in technology use and access to computers are related to both frequency and type of technology use by students. In terms of frequency of use, teachers' self-rated proficiency, the number of computers in the lab, and pedagogical beliefs were non significant predictors. After I excluded those three variables, I included teacher training, computers in the classroom, and availability of the lab in Model 3, which explained 17% of the variance in the frequency of technology use by students. Students who have teachers with more training, more computers in their classes, and have more availability to the computer lab use technology more frequently, regardless of their teachers' pedagogical beliefs.

The results for type of use tell a similar story. In Model 3, of all the predictors explored, only training and availability of the computer lab were significant, with the model explaining 9% of variance in type of use of technology by students. Although pedagogical beliefs approached significance, I chose to exclude that variable because when I tested it in Model 3, only 2% more variance was explained (p = .06). The variable of class computers was another variable that approached significance, and I chose to exclude it as well. These marginally significant variables may have merit in future studies with some of the limitations of this study removed or reduced, which will be addressed later in this chapter. Comparing the models, the best predictor of how many types of technology a teacher reports students using is a combination of teachers' training and availability of the computer lab. Students who have teachers with more training and more availability to the computer lab will use more types of technology. The results also show that having more computers in the class and favoring constructivist beliefs may also increase type of use, but this potential relationship needs further study.

In Model 3 for frequency of use, the results provide evidence that the number of computers in the class is a significant predictor. However, this effect of classroom computers could be misleading because a large number of teachers (n = 98, 58%) in the sample reported having no computers for students to use in their classrooms. In addition, another 48 teachers (29%) reported having only one to two computers for students to use. By comparison, 10% of the middle school teachers in the USEIT study had no computer in their classrooms (O'Connor, Goldberg, Russell, Bebell, & O'Dwyer, 2004). What can explain the variance in frequency of student technology use?

One explanation is that even the few computers in the class might be used frequently; it is possible that teachers are very effective at integrating one or two computers. However, other data offer alternative explanations. A majority of teachers reported that their school had at least one laptop cart. Fully 62% of the teachers responded that they had a laptop cart in the school, although the number of computers on the carts varied. Laptop cart use could have inflated the frequency of use, because if a teacher used the laptop carts at any time, it would have increased the frequency of use without being considered a "computer in the classroom." Another explanation is that frequency of use is over-reported due to the response choices on the survey. For example, one could argue that a teacher is answering truthfully about students using online research "several times a week" but that frequency might not involve many students over time if there are only one to two computers in the class. In a situation such as this, statistical significance might exist, but with few students getting opportunities for interaction with technology, the practical significance would be negligible. Graphing calculators were counted as a technology type, but not as a "computer." Future research investigating actual daily classroom computer use and clarifying descriptions of technology resources would help address these issues.

Having computers in the classroom is related to frequency but not type of use. In addition, the number of computers in a lab does not appear to be related to either frequency or type of use. The absence of a lab effect also deserves analysis. For example, only five teachers (3%) reported having no computer lab in the school. Limited variation in the numbers of computers in all the labs together could have affected the regression analysis, which benefits from variation. However, if the lab effect is arguable, the importance of *availability* of the lab is not. In addition to the regression analysis showing that availability of the computer lab is a predictor for both frequency and type of use, many teachers commented in constructed response items that the labs were difficult to access, most often because of testing.

The qualitative responses provided several important themes. Most teachers reported that their preparation to use technology in the classroom was adequate. Many teachers explained their college courses, prior jobs, and years of self-teaching and professional development had contributed to their technology proficiency. Unfortunately, when classroom computers were unavailable, teachers reported their interest and motivation in using technology with their students waned. Teachers reported technology resources were lacking and computer access was limited, which they felt obstructed the frequency with which their students could use technology. Only 3% of the teachers in the sample reported that they did not have a computer lab, and of those who had a lab 44% reported that their lab had over 20 computers, and 46% reported that the lab ratio of students to computers was 1 to 1. However, teachers reported that scheduling time to use computers, whether that meant using the lab or a mobile laptop cart (which typically have 20+ computers, making it a mobile lab) was a consistent challenge, especially with state testing occurring, reducing access to labs. Even laptop carts were reported as being designated for testing only.

Although pedagogical beliefs were inconsequential in the regression analyses, teachers' comments reflected a theme of change in their teaching because of student use of technology. Some of their comments indicated that they were teaching in constructivist ways and their students were engaged with constructivist type activities using technology.

However, many teachers also reported they were using technology to support didactic teaching, such as reinforcing what was previously taught or enhancing their instruction. Comments from teachers on student classroom use of technology often reflected *teacher* use of technology, rather than use of technology by the students themselves, which describes the complexity of the classroom circumstances and brings up the issue of what counts as technology use in the classroom. A case can be made that when resources are limited, "teacher-centered" technology use by a didactic teacher is the most appropriate use (i.e., cost effective and expedient), because the teacher is modeling technology use for the students. Didactic uses of technology by teachers might have been underrepresented in the survey items that focused only on student use of technology.

The pedagogical beliefs index may not be a valid predictor of student technology use given the variety of school circumstances that influence technology access. Teachers' self-report may inaccurately reflect their true beliefs about teaching, or teachers might be conflicted about their philosophies. For example, in the Ms. Hill-Mr Jones vignette, 54% felt more comfortable with Ms Hill's type of discussion (didactic), but 56% felt students would gain more skills in Mr. Jones' type of discussion (constructivist). Over 20% of the teachers could not decide in which type of classroom discussion students would gain more knowledge or skills. In all, 35% of the teachers could not decide if they were an "explainer" or a "facilitator," but nearly 80% felt that students should help establish criteria on which their work will be assessed. These results show some mixed feelings about their philosophy in different circumstances.

Limitations

In the current study, the inherent weakness of self-reported beliefs or philosophies is acknowledged, as social desirability bias becomes a factor, a point noted in previous studies (Burstein et al., 1995; Ravitz, Becker, & Wong, 2000; Russell, O'Dwyer, Bebell, & Miranda, 2004). But for the construct of pedagogical beliefs, construct validity and reliability are strengthened to some degree by the use of identical survey items tested previously in the TLC and USEIT surveys. As I discussed in Chapter 2, the authors of the TLC and USEIT studies conducted validation studies to check the self-reported responses about beliefs, and they found that the questions on their survey appeared to be reliable estimates of observable behavior.

Differential selection of participants, involving both the survey delivery method and “setting”, were threats to the internal validity of this study. The differential selection threat occurred at two levels. As the initial contact, the principal was the primary “gatekeeper” of access to the teachers. I attempted to control this threat by requesting that the names and e-mail addresses be sent directly to me, so that I would send the invitation to participate directly to respondents. If I obtained the names and e-mails, all respondents would receive the same invitation to participate. However, if a principal acted as the conduit to the teachers, I could not control the communications from the principal to the teachers, which could possibly promote or discourage participation and may have influenced the participation rate.

The second differential selection threat occurred at the teacher level. First of all, teachers who have an unfavorable view of technology, or those who have low self-efficacy in using technology, or do not use e-mail at all, may self-select out of participation in a technology survey from the outset. The e-mail method of delivering the invitation might be easy to ignore or overlook. E-mail reminders were one way I tried to prevent non-responses. Teachers had the opportunity to accept or decline an e-mail invitation, but to encourage participation, I advertised an easy-to-use, convenient, minimally intrusive online survey, which could be completed from any Internet-connected computer, at home or school. I also offered a small incentive and appealed to the sense of middle school mathematics affiliation with the statement "I am contacting all 7th and 8th grade mathematics teachers in the state's public schools." My response rate of 55.7% suggests that this threat was minimal in my study.

The sample became a sample of convenience due to the self-selection of principal and teacher participants, but the sample was a fair representation of the state's 7th and 8th grade mathematics teachers in age, years of experience, gender, and locale. In comparison to the state's demographics, this study's sample had 7% more females than their proportion of the state's middle school mathematics teachers and 7% more suburban schools represented than the state's proportion of suburban schools. The sample had slightly lower percentages of rural and town schools represented compared to the respective state categories. When the initial list of schools was obtained, 33 schools were eliminated for various reasons (e.g. a start up school, grade levels mixed with 6th grade, school within-a-school, etc.) and it is possible variation in technology use was reduced if those schools happened to be highly infused with technology. However, using data obtained from the Oregon Department of Education, it appears that the technology resources of schools in the sample are comparable to national averages. Comparisons of the computer resources across different locales also appears to be equitable (USDOE, 2003; Wenglinsky, 1998).

The setting where each respondent took the survey could have influenced the validity of the responses. For example, negative influences of a school setting that could not be controlled might be the noise level of the classrooms or hallways or interruptions that might occur while the respondent was taking the survey. A survey taken at home would have different conditions than a survey taken at school. Respondents also took the survey at different times of the day. The survey had a "return to survey later" feature that might increase response rates but might also threaten validity if the respondent chose to finish in a completely different environment. The threat of attrition might be considered to be those respondents who started but did not finish the survey (n = 14, 7%). Although these threats could not be controlled, I have no reason to believe they unduly influenced my results.

A post-hoc reflection about the survey instrument offers a chance to examine the threat to statistical conclusion validity (Shadish, Cook, & Campbell, 2002), in terms of measurement error, violations of assumptions of statistical tests, and restricted range of a variable. As noted in the introduction, the term technology is open to interpretation, with some defining it broadly, and others narrowly. Although I provided the definition of technology in the survey, clarity would have been strengthened by confining terminology to computers only, reducing measurement error. For example, regarding the 'presentation' type of use, I discovered through the qualitative responses that many teachers involved their students in presentations of their work through newly acquired document cameras, which project a page of text onto a large screen. In this way, students in a mathematics class are likely to be projecting their written work much like an overhead projector. In future research, this type of use needs to be differentiated from a "digitally created" presentation, such as Powerpoint, which requires more technology skill and a computer. A second type of use frequently mentioned by teachers was the interactive whiteboard, which is also being used more in schools. The interactive whiteboard is a primarily a presentational tool that can also be used by students to "interact" with the graphics, animations, navigation, websites, etc. via a touch screen, pen or mouse. If teachers considered this a form of student engagement, would its use indicate a constructivist practice? These two types of use should be measured explicitly in future studies.

I also discovered in the qualitative data that some schools have more than one lab, so the questions related to computer labs at the school might have been confusing. In addition, some teachers reported that they have more than one laptop cart, and those carts might have over 20 computers. A laptop cart essentially adds another computer lab on wheels, and responses may have been affected. On the response for number of computers in the lab, the 1-1 response was assumed to be more than 20 computers, e.g. maybe 20-30, but some respondents may have been confused if their class has less than 20 students or less than 20 computers, but still considered the student to computer ratio as being 1-1.

To avoid violations of statistical test assumptions, I tested for normality, linearity, and homoscedasticity. The dependent variable type of use was slightly heteroscedastic, and its p-plot displayed slight deviance from normality, but the plots were judged not to show too strong an evidence of violations. Methods to correct for these violations, such as using statistical transformations, were not performed in this case, but such methods might produce stronger relationships.

The range of the variable type of use was also limited (0-12), which may have weakened the relationships between the variables, and threatened statistical conclusion validity. Developing a more distinct model of use, one that more clearly distinguishes the varieties of each broad type category would increase the variation in the outcome variable.

Constructivism itself is not easy to understand, so teachers may not have connected the philosophical and psychological foundations of constructivism to how they engage the students in activities, including those activities that are technology-related (Windschitl, 2002). In countering the "traditional" classroom, teachers may believe that assigning projects or having students work in groups is achieving a constructivist purpose. As noted in the literature, standards use constructivist language, and varied teaching practices, such as working in groups, developing projects, or having input on criteria have become commonplace in schools (Burbules, 2000).

Linking Findings to Previous Research

A point of interest in this study was to test the previous findings that a constructivist teacher uses more technology with students, with greater variety, than a didactic teacher. It should be noted that the literature review framed pedagogical beliefs as a didactic-constructivist dichotomy following previous research and as a way to initiate the main argument. However, a more authentic representation of pedagogical approaches would be that didactic and constructivist pedagogy are positioned on each end of a continuum. The "pedagogical belief index" developed by Ravitz, Becker, and Wong (2000), and used in part by Higgins and Russell (2003), represents the degree of didactic or constructivist belief in the form of a continuous variable. As a further example, Becker (2000) used the continuum representation by dividing the ranges of pedagogical beliefs into quartiles, and comparing those groups.

In this study, I found no relationship between pedagogical beliefs and the frequency or type of technology use by students. One explanation is that my sample did not oversample technology-using teachers in technology-rich schools as in previous research studies. To illustrate: Ravitz, Becker and Wong (2000) included schools with extensive technology resources, technology-using teachers, or schools that had progressive curricular programs. Higgins and Russell (2003) purposively selected schools from mostly suburban schools around Boston, which had established technology programs, and whose districts requested the study to be conducted. My sample comprised "regular" teachers in "typical" public schools, in only two grades in one content area subject, and I did not purposively identify technology-using teachers or schools that had technology-rich programs. Instead, my aim was to achieve a reasonable demographic comparison to all middle school mathematics teachers in the state of interest. Because I did not purposively select technology-using teachers, or schools with extensive technology programs, the variation in technology use of the sample in this study might have been less than that found by prior researchers. It could be that when the TLC survey

(Becker & Anderson; 1998) was used, schools had fewer computers in general, which made the purposive sampling necessary. A decade later, the technology resources have increased, the student to computer ratio has dropped considerably (NCES, 2006), and many reports claim technology resources are adequate (Cuban, 2001; Ertmer, 2005; Russell, O'Brien, Bebell, & O'Dwyer, 2003).

However, in my study, the lack of predictive power of the pedagogical belief index may have been affected by two other results: (a) nearly 60% of teachers reported that they had no computer in their classroom for students to use, and (b) many teachers answered in the *never* category for types of use. For example, 61% of teachers never used databases, 55% never used e-communications, 46% never used spreadsheets, 43% never used simulations, and 45% never used word processing, all indications of low technology use in the classroom. Becker (2000) found the relationship between beliefs and technology use was substantially increased when teachers had an average amount of knowledge and convenient access to a cluster of computers.

It is possible that instead of constructivist pedagogy predicting student technology use, teacher technology use or student technology use may help a teacher develop into a more constructivist teacher. This possibility is supported by previous research (Ravitz, Becker, & Wong, 2000) that found that teachers who used technology frequently shifted toward constructivist practices over time. Ertmer (2005) supported this finding by reporting that not only do beliefs often precede behavior, but beliefs can change after instructional practice changes, such as when implementation of technology in the classroom at some modest level is successful.

When I analyzed the correlation between the pedagogical beliefs index and different types of use, I found one type of use (drill and practice) with a weak negative correlation (-.19) to constructivist pedagogical beliefs and one type of use (e-communications) with a weak positive correlation (.27) to constructivist pedagogical beliefs. These results point to potential implications of low-level and high-level types of use supported in previous research by Wenglinsky (2005). In his analysis of NAEP test data, high-level technology uses, such as simulations and applications of mathematics concepts were associated with higher achievement in mathematics, and frequent use of lower-level type, such as drill and practice were associated with lower mathematics achievement.

In retrospect, the variable *type of use* used in my study might more appropriately be designated as *range of use*. Range of use would capture the complexity of technology uses in a classroom, and include several dimensions of use. For example, Lowther, Grant, Marvin, Inan, Cheon, and Clark (2005) published a model from the North Central Regional Educational Laboratory that described technology uses along three axes: (a) instructional approach to learning, from didactic to constructivist; (b) complexity of learning, from basic skills to higher-order; and (c) authenticity of learning, from artificial to real-world context. Thus, each type of use, such as drill and practice, spreadsheets, online research, etc. would each be considered in light of these three dimensions, and might more accurately measure technology usage nuances.

In general, teachers' responses did not reflect a lack of comfort with technology, although some teachers were concerned about technology's overemphasis at the expense of other priorities. Views emerged from the constructed responses that technology could distract from the content and that the development of mathematical skills can occur without technology. These concerns reflect not only on teachers' instructional goals but on institutional goals and state and national agendas as well. With a history of low performance on statewide assessments, mathematics teachers in particular are accountable for their students' testing performance, and they may now have additional responsibilities with the goals for technology literacy (state technology standards), outlined by the state and federal government (NCLB, 2002) and presented previously in Chapter 2.

Implications of This Study

My findings suggest that student use of technology is not affected by teachers' pedagogical beliefs, but convenient access to technology and training in technology, may be more important than teachers' pedagogical beliefs when predicting technology use by students. The implications for schools and districts are that resources need to be accessible, and training needs to be pertinent to both the curriculum and the available resources. Like Higgins and Russell (2003), who found that less than 30% of teachers approved of district plans to implement classroom computers, there are more factors involved than just putting computers in classrooms.

My findings suggest that in addition to convenient access, training is important for both frequency and types of technology that teachers will have students use. Training would appear to be especially important for integrating the complexities of types of use (or range of use as described above). In addition, inferring from teachers' responses to the constructed-response questions, it appears that teachers either have adequate training and confidence in using technology, or they are willing to get training and apply it if they have the resources.

In this study I investigated pedagogical beliefs because the literature indicated that teacher beliefs were a barrier to student use of technology (Becker, 2000; Ertmer, 2005). However, the findings of this study still might point to a useful technology integration model, involving access and training, and based on my findings I would suggest that access to technology resources is the first requirement. Access would be followed in importance by training, which would include appropriate connection of the hardware and software capabilities to curriculum purposes, or lesson objectives. Pedagogical beliefs, especially when they are more clearly understood in the context of didactic or constructivist technology use, would be a third component of this model. Using resources wisely and training teachers appropriately would conceivably save districts time and money.

Perhaps at a certain level of technology integration, knowing about teachers' pedagogical beliefs might predict the level of student technology use, but the external barrier of convenient computer access, which was mentioned by Ertmer (2005) and Becker (2000), overshadowed the beliefs factor in my study. Ertmer (2005) called the internal barrier of teacher beliefs "the last frontier," because the external barriers, such as resources and professional development are reported to have been adequately addressed. Although the results of my study suggest training may be adequate, the assumptions that access is adequate and beliefs are an obstacle appear to be mistaken. Studies that have identified pedagogical beliefs as an important variable when resources are adequate may not have taken mandated testing programs into consideration. In this study, not only did computer technology appear to be inadequate in the classroom, but school labs were not available regularly for use due to testing.

National data show that schools have adequate technology resources (NCES, 2006), but perhaps those resources are not present at the classroom level, the place where teachers are most likely to use them (Wenglinsky, 2005). Technology integration in the seventh- and eighth-grade mathematics classes of this study does not appear to benefit from just having numerous computers in labs. Mandated testing has limited or even blocked access to computer labs for classroom teachers in the state where my study took place, which may be an unintended consequence of the accountability goals of NCLB. Although NCLB has set a goal for technological literacy for every child and Congress has provided funding for infrastructure and training (Chapman, 2000), computer lab access is not convenient enough for the mathematics teachers in this sample to consistently involve their students. In an unexpected way, efforts to achieve both federal goals of technological literacy and accountability may be in competition for the same resources.

Future Research

In consideration of the results of this study, future research should examine how contextual factors, such as an increase in classroom access to computers, might change teachers' pedagogical beliefs, if necessary. More research might establish in what circumstances beliefs drive practices or in what situations practices change beliefs. In addition, pedagogy, content, *and* technology use may be influenced by one another in ways not yet understood. Mishra and Koehler (2006) have identified technological pedagogical content knowledge as a concept representing the cross-section of these areas, which establishes a new research direction with implications for professional development. For example, although some educators might believe that content drives the pedagogical decisions in the classroom, emerging technologies offer teachers new tools to explore content that might change pedagogical approaches. Thus, in some cases, technology may drive the decisions and the content (Mishra & Koehler, 2006), and challenge the notion that technology is value neutral.

The qualitative data obtained in this study leads to important future investigations. If the dichotomous framework of didactic-constructivist is considered more like a continuum, then it is likely that a teacher moves back and forth along the continuum depending on the circumstances. A future study might investigate what circumstances allow instructional choices, and what circumstances dictate instructional constrictions. In such a study, the “degree” on a didactic-constructivist scale would be related to objectives and possibly change according to classroom context, technology training, and resources. Rather than a dichotomous label, pedagogical belief would act more as a “lens”, a perspective on teaching practices and technological applications being based on classroom contingencies. Teachers must, as Wenglinsky (2005) proposes, give up their “pedagogical neutrality” (p. 16) when it comes to using technology.

Technology applications (software) are a case in point. Software needs to be evaluated for its potential uses in constructivist or didactic teaching. Chapman (2000) reported that the Department of Education listed 20,000 educational software titles in

1996. Teachers may not have the time to evaluate the resources available to them for either specific or multiple purposes. Future studies might apply more scrutiny to software selection, in addition to determining if the same type of software is used differently by didactic and constructivist teachers.

In this study graphing calculators were included as a type of technology because they are common in a mathematics classroom. I did not investigate the pedagogical approaches to using graphing calculators. Using graphing calculators for only computations is different than using them for graphing or complex problem solving. Wenglinsky (2005) reported that higher-level uses of technology in a constructivist environment resulted in higher mathematics scores in the NAEP test. A future study might examine the multiple uses of graphing calculators in a didactic or constructivist environment and compare standardized test scores of the groups that would use these calculators in different ways, with a control group that would not use graphing calculators at all.

Although educational budgets are currently quite strained, the purchase of more technology resources is likely to increase. A future study might analyze the placement and persistent use of computers. Computer deployment can now occur in a lab, a library/media center, or a laptop cart, as well as in a classroom. Even as laptop access is increasing, some schools that adopted laptops for all students have cancelled their laptop programs entirely (Hu, 2007). It has been reported that teacher training is a key factor in a classroom where the ratio is one laptop per student. Studying the pedagogy used in a laptop classroom, or in a computer lab, would be interesting as technology resources increase in schools. Have some schools reached that tipping point, where teachers must truly relinquish some of the control of instruction to a machine? Beliefs related to technology use and pedagogy may be best studied in a technology-saturated school. Future research investigating the daily classroom computer use would help address this issue. Such studies would not only encourage teachers to think seriously about how best to use technology in the curriculum on a daily basis, but it might also help them to prepare students for challenges in an ever-changing technological society.

APPENDIX A

TEACHERS' PEDAGOGICAL BELIEFS AND STUDENT USE OF TECHNOLOGY SURVEY

Teachers' Pedagogical Beliefs and Student Use of Technology Survey

In this survey, technology refers to...computers (desktops, laptops, related hardware and software), peripherals (digital cameras, music players, printers, LCD projectors, etc.) and all its uses (word processing, spreadsheets, video editing, email, Internet use, web-based programs, etc.).

1. What is your school email address? (tracking purposes only, all responses remain confidential)

2. How many years have you been teaching, including this year?
    - ○ 1 year
    - ○ 2-4 years
    - ○ 5-10 years
    - ○ 11-15 years
    - ○ 16-20 years
    - ○ Over 20 years

3. Please mark the range for your age.
    - ○ 20-30
    - ○ 31-40
    - ○ 41-50
    - ○ 51-60
    - ○ 61+

4. What is your gender?
    - ○ Male
    - ○ Female

5. Does your school use block scheduling?
    - ○ Yes
    - ○ No

6. **Before you started teaching**, rate your level of technology proficiency?
    - ○ Beginner
    - ○ Novice
    - ○ Intermediate
    - ○ Expert

7. Rate your **current level** of technology proficiency.
    - ○ Beginner

○ Novice
○ Intermediate
○ Expert

8. Estimate how much professional development training in technology you've received since you have started teaching?

○ None
○ Very little
○ Moderate amount
○ Quite a bit
○ Extensive

9. Please comment how your background, experience and professional training have prepared you to integrate technology into your curriculum.

10. Indicate the number of computers and their **availability to your class** in the following rooms:

	Number of Computers	Not Available	Rarely	Usually	Always
Classroom					
Computer lab					
Media Center					

11. Please comment how you resolve issues of computer availability and access for your students.

12. What mathematics curriculum/textbook do you use?

13. Which software applications (if any) have offered the best support for students to achieve mathematics standards?

Your Teaching Philosophy

The following paragraphs describe teaching approaches in two different classrooms.

In Ms. Hill's classroom:	In Mr. Jones' classroom:
Questions are teacher-initiated Content is focused on basic levels of knowledge Structured activities shaped by teachers Emphasis on subject area content knowledge Objective view of information/knowledge	Questions are student-initiated Content is focused on complex levels of knowledge Unstructured activities shaped by students Emphasis on social network's use of content knowledge Subjective view of information/knowledge

After reading the vignettes below, answer each question below by marking the circle under the column that best answers the question for you.

Ms. Hill was leading her class in an animated way, asking questions that the students could answer quickly; based on the reading they had done the day before. After this review, Ms. Hill taught the class new material, again using simple questions to keep students attentive and listening to what she said.	Mr. Jones' class was also having a discussion, but many of the questions came from the students themselves. Though Mr. Jones could clarify students' questions and suggest where the students could find relevant information, he couldn't really answer most of the questions himself.

	Definitely Ms. Hill's	Tend towards Ms. Hill's	Can't decide	Tend towards Mr. Jones'	Definitely Mr. Jones'
14. Which type of class discussion are you more comfortable having in class?	○	○	○	○	○
15. From which type of class discussion do you think students gain more knowledge?	○	○	○	○	○
16. From which type of class discussion do you think students gain more useful skills?	○	○	○	○	○

Indicate how much you disagree or agree with each of the following statements about teaching and learning.

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Slightly Agree	Moderately Agree	Strongly Agree
17. Teachers know a lot more than students; they shouldn't let students muddle around when they can just explain the answers directly	○	○	○	○	○	○
18. A quiet classroom is generally needed for effective learning	○	○	○	○	○	○
19. It is better when the teacher – not the students–decides what activities are to be done	○	○	○	○	○	○
20. Student projects often result in students learning all sorts of wrong "knowledge"	○	○	○	○	○	○
21. Students will take more initiative to learn when they feel free to move around the room during class	○	○	○	○	○	○
22. Students should help establish criteria on which their work will be assessed	○	○	○	○	○	○
23. Instruction should be built around problems with clear, correct answers, and around ideas that most students can grasp quickly	○	○	○	○	○	○
24. How much students learn depends on how much background knowledge they have–that is why teaching facts is so necessary	○	○	○	○	○	○

Different teachers have described very different teaching philosophies to researchers. For each of the following pairs of statements, mark the circle that best shows how closely your own beliefs are to each of the statements in a given pair. The closer your beliefs to a particular statement, the closer the circle you mark. *Please mark only one circle for each set.*

25. "I mainly see my role as a facilitator. I try to provide opportunities and resources for my students to discover or construct concepts for themselves."	○	○	○	○	○	"That's all nice, but students really won't learn the subject unless you go over the material in a structured way. It's my job to explain, to show students how to do the work, and to assign specific practice."
26. "The most important part of instruction is the content of the curriculum. That content is the community's judgment about what children need to be able to know and do."	○	○	○	○	○	"The most important part of instruction is that it encourage "sense-making" or thinking among students. Content is secondary."
27. "It is critical for students to become interested in doing academic work-interest and effort are more important than the particular subject-matter they are working on."	○	○	○	○	○	"While student motivation is certainly useful, it should not drive what students study. It is more important that students learn the history, science, math and language skills in their textbooks."
28. "It is a good idea to have all sorts of activities going on in the classroom. Some students might produce a scene from a play they read. Others might create a miniature version of the set. It's hard to get the logistics right, but the successes are so much more important than the failures."	○	○	○	○	○	"It's more practical to give the whole class the same assignment, one that has clear directions, and one that can be done in short intervals that match students' attention spans and the daily class schedule."

Select your typical class, or a class in which students used technology most often. During class time, how often did students perform the following activities this year (or last semester)? Select one level of frequency on each item.

	Never	1-2 times/year	several times/yr	several times/mth	several times/wk
29.Use drill and practice software	○	○	○	○	○
30. Use an integrated learning system	○	○	○	○	○
31. Use word-processing	○	○	○	○	○
32. Use spreadsheets	○	○	○	○	○
33. Use databases	○	○	○	○	○
34. Use presentation software	○	○	○	○	○
35. Use graphics/visualization software	○	○	○	○	○
36. Use a graphing calculator/PDA	○	○	○	○	○
37. Use e-communications (video, audio, data, online)	○	○	○	○	○
38. Perform online research	○	○	○	○	○
39. Use simulations	○	○	○	○	○
40. Solve problems using real-world situations/data	○	○	○	○	○

41. For the class example you chose above, how would you rate the class' overall ability level in math? Estimate the class as a whole.

- ○ Low ability
- ○ Below average ability
- ○ Average ability
- ○ Above average ability
- ○ High ability

42. If applicable, in what ways has student use of technology changed your instructional philosophy?

43. Is there anything else you would like to comment on that hasn't been addressed in this survey?

44. Would you be willing to participate in a follow up focus group to clarify your responses?
   - ○ Yes
   - ○ No

45. Please make a choice for your $5.00 gift card
   - ○ Starbucks
   - ○ Blockbuster
   - ○ None

Thank you for your time in completing this survey

APPENDIX B

E-MAIL REQUEST TO PRINCIPAL

E-mail Request to Principal

Dear Principal,

My name is Dennis Jablonski and I am a PhD candidate at the University of Oregon in the Educational Leadership program. I am conducting a study on teachers' instructional philosophies and their use of technology with students (even if technology is not used frequently). This study has been approved by the university's Office for Protection of Human Subjects, and it is supervised by Dr. Gerald Tindal, Department Head of Educational Leadership.

I would like to collect the background, opinions and experiences of your 7th and 8th grade mathematics teachers in a brief online survey. I'm contacting every public middle school in Oregon to get a broad-based representation of teacher viewpoints. This survey will take approximately 20 minutes to complete, is voluntary and confidential. No names of persons, schools or districts will be disclosed or associated with any of the data for any reason. Teachers can access the survey at any time, and from any computer (including home).

If you would like to forward this email to your office staff, that person can email me with the name(s) and email(s) of your 7th and 8th grade mathematics teacher(s). If I don't hear from your staff, I will follow this initial request with a phone call. Teachers will have the option to decline, but I'm offering them a $5.00 gift certificate for their time and effort. I appreciate your cooperation.

Thank you,

Dennis Jablonski
Graduate student, University of Oregon
djablons@uoregon.edu
(541) 123-4567

Research Advisor:
Dr. Gerald Tindal
Department Head, Educational Leadership
geraldt@uoregon.edu
(541) 123-4567

APPENDIX C

E-MAIL INVITATION TO PARTICIPATE

Email Invitation to Participate

Dear teacher,

As a teacher in the public sector since 1991, I know your time is valuable. I invite you to participate in a research study on teachers' instructional philosophy and the use of technology with students (even if technology is not used frequently). My name is Dennis Jablonski and I am a PhD candidate at the University of Oregon, in the Educational Leadership program. I obtained your contact information from the principal/office staff.

This study focuses on the background, opinions and experiences of middle school teachers, so I am contacting all 7th and 8th grade mathematics teachers in Oregon's public schools to get broad-based representation.

If you decide to participate in this study, you will be asked to complete an online survey, taking approximately 20 minutes. You can access the survey at any time, and from any computer (including home). The multiple-choice format is easy to use and the open-ended questions will offer an opportunity for you to share your opinions and expertise. In appreciation of your time and effort, I am offering you a $5.00 gift card from Starbucks or Blockbuster.

Participation in this study is completely voluntary and you may withdraw at any time; all information will remain strictly confidential, and all data will be destroyed at the conclusion of the study. When you're ready to participate, click on the link below. The introductory page will be the consent form to participate in the study. If you have any questions about the study, please email me at djablons@uoregon.edu, or contact me at (541) 123-4567.

Thank you very much.

Sincerely,
Dennis Jablonski

Click the link below to access the survey. Your responses are greatly appreciated.

Link: http://XXXXXXXXXXXXXXXXXXXXXXX

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