

Technology Integration: A Review of the Literature.

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Abstract

Technology has been viewed as a lodestone for improving student academic performance and for increasing the flexibility of public schools. This review provides a synthesis that addresses the effect of technology on teaching and learning and analyzes these effects through the lens of diffusion theory. This synthesis examines the historical trends of technology, explores policy changes that have influenced technology's role in K-12 curriculum, how these changes have resulted in a new definition of literacy that now includes technological literacy and in new social and cultural dynamics. Third, this review examines the gaps between the vision for technology and its practical realities, concluding with a call for future educational research in technology.

Throughout the past few decades, technology has been viewed as a lodestone for improving student academic performance and for increasing the flexibility of public schools. During this time, computer availability and use in the nation's K-12 public schools has increased and programs addressing educational technology have gained attention. The vision and promises of technology have been vast. In his 2005 book *The World is Flat*, Friedman discusses a world in which the Internet facilitates instantaneous communication and connections. This necessity to compete in the increasingly shrinking world economy accentuates the importance of today's children gaining familiarity and competence with technology applications. Technology has been viewed as a way to circumvent learning difficulties and to advance more efficient learning; it has been viewed as a means to end inequity and inequality within public schools and to provide access to learning outside the K-12 classroom. The growing interest has had an impact on education and has produced a vast body of literature. This review provides a research synthesis of the field that addresses the effect of technology on teaching and learning.

To best understand the impact technology has had on the field of education, this synthesis first examines the historical trends of technology in U.S. schools over the past few decades and provides a benchmark for how technology's impact on schools has evolved. Second, this synthesis explores how policy changes have influenced technology's role and affected the K-12 curriculum, as well as how these changes have resulted in a new definition of literacy that now includes technological literacy and in new social and cultural dynamics of technology and schools. Third, having detailed historical trends and the impact of policy changes in technology, this synthesis examines

the gaps between the vision for technology and its practical realities. Finally, the synthesis concludes with a call for future educational research in technology that attends to these aforementioned gaps.

After decades of studying the impact of technology on schools, the education technology field is calling for “research that makes a difference” (Roblyer, 2005). Leading scholars in the field have recently started a discussion to examine the complexity of educational technology scholarship through the lens of evidence-based research (Dawson & Ferdig, 2006; Dede, 2005; Roblyer, 2005; Schrum et al, 2005). Recognizing the need for “a more organized and persuasive body of evidence on technology’s benefits to classroom practice” (Roblyer, 2005, p.192), the scholars behind the movement are pushing the field to design and implement research that will address technology’s pedagogical contributions while at the same time meet the standards of evidence-based research.

The research on technology use in schools focuses primarily on computers and/or Internet usage with less emphasis on other technologies such as video, graphing calculators, and handheld devices. Therefore, in this article, the terms technology and computers are used interchangeably. Although considerable international research on technology and the culture of learning exists, the review focuses solely on technology and teaching and learning within the context of K-12 schools in the United States. The focus is purposefully on U.S. K-12 schools to allow a thorough synthesis of the immense body of literature related to computers in U.S. schools. By restricting the review to U.S. literature, we were able to focus in greater depth on the issues directly related to U.S. policy and schooling.

Methodology

The literature search included sources from the 1960s to the present in which technology innovation or technology integration into K-12 schools were the focus. Although sources as early as the 1960s were reviewed, the primary publications were selected from the years between 1985-2008 because of the great changes in computers and the immersion of computers in schools during this time period. The extant literature was specifically reviewed to address the question, “What has been the effect of technology on teaching and learning?”

Criteria for Inclusion

In selecting studies for inclusion in this review, over 600 potential sources were reviewed, abstracted and analyzed with a total of 176 cited in this article. The following criteria were used to select the studies that were reviewed:

1. Direct relevance to the topic, i.e. those addressing technology use in schools, teacher use of technology, student use of technology.
2. Literature published predominantly from 1985-2008.
3. Studies conducted within the United States.
4. Studies addressing K-12 schools.
5. Empirical studies using a variety of methodologies, including descriptive studies, quantitative studies, and qualitative studies.
6. Literature reviews, doctoral dissertations, and reports which contain rigorous research.

An initial search of the Education Full text database, the ERIC database, and the ProQuest dissertation database was conducted using the search terms and variations of

“technolog*,” “comput*,” “digital,” “school*,” “K-12,” “students,” “teach*,” “integration,” “elementary,” “secondary”. Secondly, selected peer-reviewed journals were reviewed such as the journals published by the American Educational Research Association, journals specific to the field of technology and education, for example the *Journal of Research on Technology and Education*, the *Journal of Educational Computing Research*, and the *Contemporary Issues in Technology and Teacher Education Journal*. Additionally online searches of Google Scholar and JSTOR were conducted as well as reviews of other scholarly journals and texts, technical and federal reports, and reference lists from technology and education journals.

Limitations of the Field

The published research in the field has significant limitations. Two major quantitative studies using survey data provide large-scale information about the use of technology in schools and provide a way to measure changes in technology use over time. These studies were conducted by the National Center for Educational Statistics [NCES] (2000, 2005, 2007) and the Center for Research on Information Technology and Organizations [CRITO] (Becker 1986; 1990; 1991; 1994; 1999; 2000a). While quantitative studies of technology use in schools do provide an overview (Hadley & Sheingold, 1993; Russell, Bebell, O’Dwyer, & O’Connor, 2003; Warren, Dondlinger, & Barab, 2008; Waxman, Connell, & Gray, 2002), they are deficient in providing a contextual understanding of teachers’ use of technology that qualitative methodologies afford. Empirical research using case study methodologies (Ertmer, Addison, Lane, Ross, & Woods, 1999; Friedman, 2006; Garthwait & Weller, 2005; Grant & Branch, 2005; Guha, 2003; Michael, 2001; Wang, 2002), has been prevalent in the past several years.

The nature of this type of research, however, is limited to small populations and overwhelmingly investigates teachers and schools who exemplify best practices, those involved in educational reform, or technology use as a vehicle of reform (Casson et al., n.d.; Glazer, 2004; Sandholtz, Ringstaff, & Dwyer, 1997; Staples, Pugach, & Himes, 2005, U. S. Department of Education, 2002; Wallace, 2004; Windschitl & Sahl, 2002).

The extant literature, although limited and predominantly focused on teacher behaviors and teacher competencies, as well as variables related to materials, facilities, and administrative support does provide some insight into uses of technology in schools (Hernandez-Ramos, 2005; Norris, Sullivan, Poirot and Soloway, 2003; Rother, 2005; Sandholtz & Reilly, 2004). Roblyer (2005) states that weaknesses in the field of educational technology scholarship “include fragmented and uncoordinated approaches to studying technology resources and strategies, methods that lack rigor or are ill-matched to the research questions at hand, and poorly written reports that render problematic subsequent attempts at replication and follow-up” (p. 192).

An additional limitation is the fact that the field of technology constantly changes at a rapid pace (Berson & Balyta, 2004). Given the fast pace with which new technologies emerge, it is difficult for the scholarship to keep up with the new technologies. With each new technology, a period of innovation must pass for the technology to be introduced. Then, researchers must design and implement studies to investigate the effects of the new technology. Finally, the researchers must prepare and submit a publication for review. The layers of academic publishing result in a delay in publication of research studies on the newest technologies. For this reason, unpublished

dissertations offer one method of informing the field of current research and innovation in a more rapid process.

Framework

Within the context of technology and learning and teaching, we identified several questions to frame the synthesis of the literature review. The questions build upon one another. Each must be considered to fully understand the current field of research related to technology and learning and teaching.

- What are the historical trends of technology in schools?
- What key policy and legislation has impacted technology in schools?
- What is the current status of technology in schools?
- How has technology impacted curriculum and pedagogy?
- How is literacy being redefined as a result of technology in schools?
- What are social and cultural impacts of technology in schools?

Following an exploration of these questions, the review discusses the impact that technology has had on teaching and learning within the framework of diffusion theory (Rogers, 1995). Rogers defined diffusion as “the process by which an innovation is communicated through certain channels over time among members of a social system” (p. 5). Diffusion theory suggests that there is a progression of technology adoption and integration. This progression begins with the introduction of an innovation and ends with its adoption or rejection and naturally occurs over-time. A review of the effects of technology on teaching and learning lends itself to analysis through the lens of diffusion theory as the phenomena of adoption occurs over time and in varying degrees.

Characteristics of the innovation that influence the rate of adoption include its relative advantage over existing ideas, compatibility with the individual or organization, how clearly the innovation can be understood, the commitment necessary to test the innovation, and how easily it can be communicated. The five main steps in the diffusion process are knowledge of the innovation, persuasion of potential adopters, the decision to adopt or reject the innovation, the implementation of the innovation, and ultimately the acceptance or rejection of the innovation. All of this occurs not only within an organizational structure but with individuals as well. For example, although the K-12 school administration embraces the innovation, an individual classroom teacher may choose to reject the innovation.

In order to understand the impact that technology has had on K-12 pedagogical issues over the past two decades, it is important to explore historical trends since the 1960s. Within this context, educators and researchers are then able to problematize the current impact of technology on schools and culture.

What Are the Historical Trends of Technology in Schools?

Educators, researchers, and policy makers have discussed educational technology for decades. Computer-assisted instruction was a topic as early as the 1960s when the promise of raising student achievement through drill and practice computer programs was suggested (Skinner, 1960). Researchers, for example, posted findings such as: “What the teacher could do in twenty-five minutes per day, the computer could do as well in five to ten minutes per student session” (Suppes & Morningstar, 1969). The LOGO (Papert, 1978) projects touted the promise of students learning computer programming -- specifically the LOGO environment – and the initial LOGO studies were among the

earliest to speculate that technology could be used for more than drill and skill activities (Papert, 1978, 1980; Pea, 1983; Thornburg, 1984). In 1985, Carmichael, Burnett, Higginson, Moore, and Pollard indicated that creative use of computers, in particular LOGO programming, fostered the development of independent and original thinking and that an environment that encouraged exploration led to extensive social interaction among students. Although these studies were often linked to artificial intelligence and focused primarily on student learning outcomes, they laid the foundation for the large trend of seeking uses of technology for educational transformation.

However, it was the research literature on the use of technology in schools, most notably, the Apple Classrooms of Tomorrow (ACOT) longitudinal study (Ringstaff, Sandholtz, & Dwyer, 1991; Ringstaff, Yocam, & Marsh, 1996; Sandholtz, Ringstaff, & Dwyer, 1994; Sandholtz et al., 1997) which began in 1985 and continued for over a decade that marked a decisive effort towards improving student outcomes. The focus became broader than student learning outcomes as the researchers attended to student learning activities, teacher behaviors, competencies and characteristics as well as teacher preparation and training. The framework and results of the ACOT studies are seminal to an understanding of technology in schools.

ACOT was a research and development collaboration among public schools, universities, research agencies, and Apple Computer, Inc. At the outset, the study consisted of seven classrooms that represented a cross-section of America's elementary and secondary schools. Over the years, the overall project goal remained to study how the routine use of technology by teachers and students might change teaching and learning (Sandholtz et al., 1997). Primarily, it cemented the notion of technology-infused

classrooms and broadly influenced much of the subsequent research/literature on the subject.

In fall of 1986, each of the ACOT sites began with one classroom per school with additional classrooms, staff, and students joining in subsequent years. “The operating principle in ACOT classrooms was to use the media that best supported the learning goal” (Sandholtz et al., 1997, p.188). The 1986 vision of technology in education of the study was more far reaching than simply putting computers in schools as teaching machines, “Technology was viewed as a tool to support learning across the curriculum” (Sandholtz et al, 1997, p. 6). This, it was suggested, could best be accomplished by supporting constructivist pedagogy.

The ACOT vision was to transform traditional *knowledge instruction* classrooms into *knowledge construction* classrooms. ACOT researchers viewed technology as a necessary and catalytic part of such a transformation. A knowledge construction classroom would emphasize problem solving, conceptual development, and critical thinking rather than rote memorization of facts that one would traditionally find in a knowledge instruction classroom. ACOT indicated that the cognitive premises of the theory of constructivism cannot dictate specific teaching methods, but instead should offer guidelines for good teaching.

It is significant to review this era in history to understand that the primary lesson learned as a result of ACOT is that technology alone cannot improve teaching and learning. Furthermore, technology must be “grounded firmly in curriculum goals, incorporated in sound instructional processes, and deeply integrated with subject-matter content” (Baker, Herman, & Gearhart, 1996, p.201). The ACOT researchers clearly

stated that the marriage of constructivism and technology could revolutionize education. The body of work resulting from the ACOT study set the vision for educational technology in schools and provided the impetus for much of the technology adoption that followed in subsequent years and set the groundwork for research on technology and learning.

In summary, the historical trends of technology in schools include a change from computer-assisted instruction focused on drill activities to a vision for educational transformation by integrating technology into curriculum. In addition to the early vision of technology as a vehicle of pedagogical reform, the historical lens of policy that follows is the second question that emerged from the review and sets a framework for making problematic current trends and outcomes.

What Key Policy and Legislation has Impacted Technology in Schools?

As the diffusion of computing technology became more widespread, public interest in technology, especially personal computing, increased the role of policy and legislation in technology integration. Technology literacy came to be viewed as a necessary basic skill by the public and policymakers alike. The federal government exerted influence and leadership in the area of educational technology by means of funding.

During the 1990s federal programs addressing educational technology gained impetus, and the United States spent billions of dollars to bring computer and Internet access to public schools (Benton Foundation, 2001). This trend carried well through the 1990s into the new millennium. At the same time, legislative interest in the 1990s marked the beginning of federal mandates related to not only access issues but also

curricular issues. For instance, *The Goals 2000: Educate America Act* enacted in 1994, was legislation designed to enhance educational technology in the nation's schools ("Goals 2000," 1994). Included with these goals was a call for all teachers to have continuing opportunities to acquire additional knowledge and skills needed to teach challenging subject matter and to use emerging new methods, forms of assessment, and technologies ("Goals 2000," 1994).

In order to accomplish these goals, a plethora of federal initiatives were implemented. Among the initiatives was the opening of the Office of Educational Technology, the development of a national technology plan, ten *Regional Technology in Education Consortia* (RTEC) were established (Regional Technology in Education Consortia, 2002), and numerous grant projects became available (U. S. Department of Education, 1996, 1998, 2000a, 2001c). National industry and educational leaders were also encouraged to collaborate on educational technology. Another key initiative in the late 1990s, *Preparing Tomorrow's Teachers to Use Technology* (PT3) grants (www.pt3.org), supported planning, implementation and the development of statewide initiatives and other national efforts to integrate technology into teacher preparation programs. This Department of Education (DOE) program awarded grants to colleges, school districts, and state education agencies in order to better prepare future teachers to integrate technology into their teaching. Over \$335 million was spent on these programs (U. S. Department of Education, 2000b). These grants, awarded at different levels, provided a vehicle for teacher educators to partner with K-12 schools around technology integration and provided a fertile research field for educational researchers.

The decade of the 1990s proved to be a great boon to educational technology. This paralleled the growth of technology in the nation, not only in the business and technology sectors but in private households as well (Solomon, 2002). Just as national policy provided support via funding for technological availability within K-12 schools in the last century, current national policy provides a focus as well.

The *No Child Left Behind* (NCLB) Act of 2001 sought to “improve student academic achievement through the use of technology” in K-12 schools. (U. S. Department of Education, 2001a, 2001b). The federal technology plan (U.S. Department of Education, 2004) indicates that systemic change is needed in order to address “the national crisis that underscores the demand for accountability in education” (p.12). The 2001 NCLB legislation superseded and eliminated many of the 1999 national educational technology goals. In an attempt to relegate authority to the states and minimize paperwork, the potential for losing the ground gained in the 1990s is great. Underlying this legislation is the notion that if educational technology is not being used to raise standardized test scores, there is no need for the technology or for its funding.

Overall, great strides were made as a result of federal policy and funding for technology in schools. As demonstrated above, policy and funding have impacted not only the integration of technology into schools, but also research on technology. As technology continues to rapidly advance and change, continued federal funding remains crucial to both the diffusion of technology but also research in the field. In light of policy and legislation, it is necessary to examine the existing status of technology in U.S. schools. Developing an understanding of the current status of technology in schools enables the field to establish a baseline for issues of availability and use.

What is the Current Status of Technology in Schools?

In late 2006, the NCES released an update of *Internet Access in U.S. Public Schools and Classrooms* (NCES, 2007). This report includes findings from similar previous reports (NCES, 2000, 2005) According to the 2007 report, nearly 100 percent of the nation's schools have Internet access. This is consistent with data reported previously. However, 94 percent of all instructional rooms had Internet access (NCES, 2007). Instructional rooms include not only classrooms but also libraries, computer labs, media centers, and resource rooms. Therefore, many classrooms do not have adequate computers or Internet access.

Without speed and access, usability of technology for instructional purposes is significantly limited. Types of Internet connections with increased speed have continued to develop. Additionally, 45 percent of the public schools with Internet access used wireless Internet connections (NCES, 2007). Since nearly 100 percent of public schools have Internet connectivity, most schools have the capability to use the web for a variety of purposes. Nationwide, 88 percent of public schools had a website or webpage (NCES, 2005). As connectivity speeds increase, schools are often still caught in a digital time warp. As advances in chip technology grow exponentially, schools continue to have limited resources and are using out-dated equipment with limited capabilities. Simply because a school is wired and Internet connectivity exists, does not mean that the students have access to current technology on a regular basis, nor does it mean that students have equal access to current technology (Lenhart & Madden, 2005).

Consistent with earlier reports (NCES, 2000, 2001, 2002, 2003, 2005), the 2007 report indicates that only one-third of the nation's teachers feel well prepared to teach

with technology. This despite the fact that by 2005, 83 percent of the schools with Internet access had offered professional development to teachers on how to integrate the Internet into curriculum (NCES, 2007).

The NCES addresses issues of access and availability, school website, Internet protections and frequency of professional development offerings. This data demonstrates that schools have technology. What this data does not tell is the access, availability and up-to-dateness of technology within classrooms, the pedagogical uses and impacts of technology, or the types of technology use within classrooms. One might expect sweeping educational changes as a result of the increased access; yet the literature does not indicate such change. Several issues relating to educational reform, curriculum, and pedagogy will be addressed in the following sections.

How has Technology Impacted Curriculum and Pedagogy?

Much of the recent literature continues to look at issues of access and availability and frequency of use, but not at the pedagogical issues related to technology and not at what teachers and students are doing with technology. In order to understand the impact of technology integration into curriculum, an examination of multiple issues is needful. Among these issues are content area standards, curriculum and pedagogy, the anticipated reform that was expected to occur as a result of technology in schools, the relationship of this vision to curriculum, the gaps between this vision and reality, and the redefining of literacy. The following sections address these issues.

Standards

Vestiges of the early ACOT (Sandholtz et al., 1997) work appear in many of the educational technology standards in existence today. The national content area organizations such as the National Council of Teachers of Mathematics [NCTM] (National Council of Teachers of Mathematics, 2000), the National Council for the Social Studies [NCSS] (National Council for the Social Studies, 1997), and the National Council of Teachers of English [NCTE] (National Council of Teachers of English, 1996) all included technology as a key strand or component in their standards documents. These documents emphasized content with technology being a tool to support student understanding of the content area.

In addition to content area standards, *National Educational Technology Standards* [NETS] (International Society for Technology in Education, 2000, 2002, 2007, 2008) serve as a guide for educators. They describe what students should know about technology such as applications and technical skills and provide curriculum examples of the effective use of technology (International Society for Technology in Education [ISTE], 2000, 2007).

Importantly, this document defined curriculum integration

Curriculum integration with the use of technology involves the infusion of technology as a tool to enhance the learning in a content area or multidisciplinary setting. Technology enables students to learn in ways not previously possible. Effective integration of technology is achieved when students are able to select technology tools to help them obtain information in a timely manner, analyze and synthesize the information, and present it professionally. The technology should

become an integral part of how the classroom functions—as accessible as all other classroom tools. (ISTE, 2000, p. 6)

The focus on curriculum outcomes instead of a single-minded focus on technology proliferation is one example of the continued philosophical emphasis of the ACOT project. In both cases technology is viewed as a tool to support learning across the curriculum; it allows students to do things that they couldn't do without technology and that the focus should be on curriculum, on student understanding and learning, can be linked to the results of the ACOT project (ISTE, 2000; Sandholtz et al., 1997).

Technology must be rooted in curriculum goals and integrated with subject matter content technology.

At the same time there is awareness that without teachers who are well prepared to integrate curriculum and instruction, K-12 students will not benefit from the potential of technology and its educational possibilities. Therefore the emphasis of *NETS for Teachers* is on teacher preparation, “a combination of essential conditions is required for teachers to create learning environments conducive to powerful uses of technology” (ISTE, 2002, p.16). In 1997, the National Council for Accreditation of Teacher Education (NCATE) adopted the *NETS for Teachers* standards for preparing preservice teachers to use technology. These standards state that preservice teachers should learn how to use computers to teach content area curriculum as well as learn how to use technology for assessment and professional productivity (NCATE, 2001).

Combined technology standards, whether for inservice teachers, preservice teachers, or teacher education faculty have resulted in concerted efforts to infuse computer technology into all levels of public education. Several teacher preparation

programs have received the ISTE NETS Distinguished Achievement Award for exemplary implementation of these standards (http://cnets.iste.org/netsawards/na_winners.html). These teacher preparation programs are from a variety of institutions and span the Carnegie Classification of Institutions of Higher Education (such as Hope College and the University of Texas, Austin). As discussed earlier, unpublished dissertations often provide the field with the most up-to-date research. It is significant to note that not only are these institutions leading the field in the area of preparing teachers to infuse technology, they are also leading the field in education technology research. Over 250 dissertations focusing on technology and education have come from the four doctoral granting institutions that received the ISTE NETS award.

Teachers' Technology Use

In September 2000, the NCES released Teachers' Tools for the 21st Century, based on the 1999 Fast Response Survey System (FRSS) that reports on teachers' use of technology and data from the 1998 administration of the National Assessment of Educational Progress (NAEP). The participants in this study included only public elementary and secondary teachers, and the results are not always disaggregated by instructional level. The Technology, Learning and Computing: 1998 – A National Survey of Schools and Teachers (Becker, 1999), a survey of over 4,000 public and private school teachers, overwhelmingly supports the findings of the NCES (2000) document. Although elementary, middle and high schools were the focus of these two studies, the data are sufficiently disaggregated by level. Their major findings from these studies were:

1. Technology is most frequently used by teachers for administrative or preparatory tasks.
2. Technology is used often by teachers for communication.
3. Technology is used by teachers for classroom instruction.

The results of the NCES (2000) study indicated that teachers used technology primarily for administrative and preparatory tasks rather than for classroom instruction. Teacher use of technology to develop classroom materials and plan for instruction does not correlate to student use of technology, nor is there a correlation to curriculum integration of technology.

Teacher preparation is a key factor to the use of technology. The NCES reports that approximately one-third of the nation's teachers indicated that they were prepared to use the Internet and computers for classroom instruction. Interestingly, less experienced

teachers felt better prepared than veteran teachers to teach with technology (NCES, 2000, 2007). The greatest barriers to technology use cited were not enough computers, lack of release time for training, and lack of time in daily schedule for student use of computers.

By 2000, significant increases had been made in access and availability to computer hardware and software and teacher preparation and training. However, computers in schools and classrooms had not dramatically changed how teachers taught or the way students learn. Although there were examples of teachers using technology in innovative ways, computers continued to be used primarily as an extension of traditional methods of teaching (Bayraktar, 2001; Becker, 2000a, 2000b; Becker & Riel, 2000; Bauer & Kenton, 2005; Cuban, 2001; Ertmer et al., 1999; Milman, 2000).

In order for technology to be used effectively in schools, several support factors need to be in place. These factors are access and availability, teacher preparation and training, leadership and time (Becker, 2000a; Becker & Riel, 2000; Calvert, 2001; Catchings, 2000; Cuban, 2001; Dawson, 1998; Evans-Andris, 1996; Guha, 2003; ISTE, 2002; Lieberman, 1995; Marcinkiewicz, 1994; Michael, 2001; NCES, 2000, 2002; Schrum, 1993, 1999).

By the end of the twentieth century, nearly all of the nations' K-12 schools had access to computers and the Internet but not necessarily in equitable or classroom friendly ways. We can also surmise from the literature that the myriad possible effective uses of technology to support instruction and link to curriculum had not been tapped. The following section will analyze the impact that technology has had on educational reform.

Visions of Educational Reform

This effort towards the effective use of technology went beyond mere classroom instruction; it was seen to potentially lead to educational reform in general. According to the ACOT study, “computers can be multipurpose tools, enhancing learning, empowering students, and situating educational innovation at the forefront of progressive educational change” (Gooden, 1996, p. xxi). For some, technology has the potential to drastically reform education, “...no magic bullet has been found that will address all of the problems and challenges of K-12 education. Nonetheless, educational technologies may be the next best thing” (Casson et al., n.d., p. 3). According to Cuban (2001), reform was the response to the 1983 report, *Nation at Risk*, by the National Commission on Excellence in Education. Technology in schools soon became viewed as a transformative panacea.

A camp of scholars who suggest a paradigm that technology integration is content specific has emerged (P. Bell & Linn, 2000; R. Bell, Park, & Toti, 2004; Berson, 1996; Diem, 2000; Wu, Krajcik, & Soloway, 2001). This has been referred to as *electronic pedagogical content knowledge* (Irving, 2003) and *technological pedagogical content knowledge* (Mishra & Koehler, 2006; Pierson, 2001; Thompson, 2005) and places an added emphasis on the role of curriculum. Likewise, simply knowing how to use technology is not the same as having electronic pedagogical content knowledge and skill (see also Shulman, 1986).

Pedagogical use of computers is different from other uses of computers (Davidson, Schofield, & Stocks, 2001; Margerum-Leys & Marx, 2002; Sprague, 2004; Wallace, 2004). Future teachers must learn to develop and implement curriculum plans that include methods and strategies for integrating technology in various subject matter areas

to maximize student learning. The school curriculum content influences what technology is used and how it is used. Assuming that electronic pedagogical content knowledge and skill will automatically transfer from knowledge of how to use a computer is akin to assuming that because someone knows geography, one knows how to teach geography. The existence of methods courses in teacher preparation programs indicates that content knowledge is not the same as knowledge of how to teach content; a parallel exists with technology.

This added emphasis on content specific curriculum has resulted in research becoming more content specific. The journal *Contemporary Issues of Technology in Teacher Education* (<http://www.citejournal.org>) publishes content specific research articles in each issue. The discipline specific professional organizations (such as Association of Mathematics Teacher Education and Association for Science Teacher Education) sponsor the content specific sections of each issue. Examples of content specific research in *Contemporary Issues of Technology in Teacher Education* include using the graphing calculator in the algebra classroom, developing multimedia projects to further develop literacy skills, using video analysis software to understand conservation of mechanical energy, and using technology resources to teach the Holocaust. The emerging emphasis on technology and the curriculum requires an examination of the relationship of technology vision to the curriculum.

Consistently, studies of technology indicate that teachers and students apply technology in ways that demonstrate low levels of integration (Cuban, 2001; Zhao, Pugh, Sheldon, & Byers, 2002). Although classroom access to technology has rapidly increased over the past decade, the most frequent and creative uses of computer technology are not

yet linked to curricula (Becker, Ravitz & Wong, 1999; Davidson, Schofield, & Stocks, 2001; Zhao et al., 2002). Teachers are more likely to have their students use technology for word processing than for any other type of activity (Becker, 2000b; NCES, 2000). Although a case could be made for the importance of a student developing word processing skills, is its use proportionate to its focus in the curriculum and academic standards? In many instances, computers are being used primarily for test-taking (Russell & Haney, 2000). *NETS* (ISTE, 2000, 2007) elaborates on the effective integration of technology and the notion that technology enables students to learn in ways not possible before. Using technology predominately for word processing and low-level activities is contrary to this vision.

The research focusing on curriculum integration, as defined by ISTE (2000, 2007), is inadequate. There is a lack of research on how *NETS for Students* (ISTE, 2000, 2007) are being addressed in curriculum and implemented in instruction. Aside from a “technology component” being included in a teacher’s manual or a CD-ROM being attached to a set of textbooks, professional curriculum developers have largely ignored technology integration.

However, there is growing, albeit limited, evidence that technology is being integrated into curriculum content in ways that do correspond to the vision (Barron, Kemker, Harmes, & Kalaydjian, 2003; Berson, 2004; Crocco & Cramer, 2005; Tally & Goldenberg, 2005; Wetzel, Zambo, & Padgett, 2001). These, and other similar studies, are typically case studies or limited to site-specific populations (individual school districts, funded technology projects, etc.). The extant literature has informed us that the

technology is not being integrated with curriculum to the degree that reformers had hoped or promised.

Realities of Reform

To date, curriculum and instruction has changed very little as a result of technology. At the beginning of the 21st century, the barriers to the use of technology for instruction most frequently reported by public school teachers were not enough computers or outdated computers, lack of release time for teachers to learn how to use computers or the Internet, and lack of time in schedule for students to use computers in class. The “great” barriers reported by teachers were not enough computers and lack of release time (Becker, 2000b, NCES, 2000). Increasingly, teachers cite high-stakes testing demands as barriers as well (Nichols & Berliner, 2005; Maddux, 1998).

Even with the technology infrastructure building that occurred in the 1990s, most schools “could not yet be described as well equipped because they did not permit routine integration of computer technology into the learning activities of most classes” (Becker, 2000b, p. 46). This is due, in part, to the difficulty schools have in keeping technologically current as technology is constantly changing. Many teachers feel pressured for content coverage. There is a gap in the research literature as to how current high stakes testing and accountability have affected technology integration in schools.

There is some indication that teachers who hold constructivist beliefs about teaching in general are more likely to have their students use the computers and the Internet (Hadley & Sheingold, 1993; Wenglinsky, 2005). These teachers tended to devote more “attention to student interest rather than curriculum coverage, focusing on critical thinking and real-world applications, and using complex problem solving in small groups

to help students learn” compared with teachers with more traditional beliefs and practices (Becker, 2000b, p.54). Other scholars (Becker & Ravitz, 1999; Mehlinger, 1996) indicate that computer-using teachers develop constructivist pedagogies over time.

The limited skill and expertise of teachers in using technology themselves is an additional barrier to professional use of technology (Becker, 2000a; NCES, 2000). To what extent this holds true is an on-going debate (Becker, 2000a; Cuban, 1986, 2001). Additionally, teachers have indicated that they do not know how to integrate technology into the curriculum (Becker et al., 1999; NCES, 2000). A correlation exists between professional development and teachers’ feeling well prepared to integrate curriculum and technology.

When the factors supporting technology and curriculum integration are in place, students and teachers use technology in visionary ways. For example, there is evidence in the field of social studies (Bolick, Berson, Coutts, & Heinecke, 2003; Friedman, 2006; Hicks, Doolittle, & Lee, 2004) that the technology experiences that teachers provide to students are beginning to change; however, it is still true that the majority of teachers use technology only occasionally with students, and some do not use technology at all (Becker, 2000a).

Contextual factors provide an explanation for the lack of widespread transformative use of technology and curriculum integration. These factors are economic, political, historical, and social. Cuban wrote that “the striking emergence of a large, diverse ad hoc coalition seeking to replicate in public schools the technological transformation that had occurred in the corporate workplace” (2001, p.156) was responsible, in part, for the emphasis of educational technology in the past two decades.

It was believed that higher productivity could be achieved by introducing new technologies into schools and therefore America wanted high tech schools. For many, a “good” school has become synonymous with a technologically equipped one.

Cuban (1986; 2001) has argued that computers are generally incompatible with the demands of teaching, and that, for the most part, teachers will shun their use by students during class. A critic of educational technology zealots who encourage school decision makers to wire classrooms, purchase hardware and software, Cuban has been skeptical of these reform efforts because the nature of traditional school and classroom organizations do not easily allow for computers to be used for knowledge construction. Oppenheimer (2003) has been critical of technology in schools as well;

The emergence of the Internet made the high-tech classroom seem like education's long-awaited savior. With missionary zeal, technology's promoters defined this initiative as nothing short of a revolution. It was supposed to do more than any reform in recent memory to revive our weakened schools and prepare today's students for tomorrow's increasingly high-tech jobs. (p.xii)

In his response to Cuban, Becker (2000a) using data from the 1998 Teaching, Learning and Computing national survey, stated, “On the issue of whether computers are generally a central vehicle of instructional activities in the classrooms, the data suggest that Cuban remains correct up to the present time” (p.27). Computers have not transformed the teaching practices of the majority of teachers,

However, under the right conditions—where teachers are personally comfortable and at least moderately skilled in using computers themselves, where the school's daily class schedule permits allocating time for students to use computers as part

of class assignments, where enough equipment is available and convenient to permit computer activities to flow seamlessly alongside other learning tasks, and where teachers' personal philosophies support a student-centered, constructivist pedagogy that incorporates collaborative projects defined partly by student interest—computers are clearly becoming a valuable and well-functioning instructional tool. (Becker, 2000a, p.28)

The social context in which educational technology has been placed plays a significant factor in the gap between the vision and reality of technology use. Certain rules, policies, and procedures must be followed that can incrementally alter the organizational, political, and cultural context of classrooms and schools. The inherent potential of technology to alter the social context of teaching has caused teachers to express ambivalence towards technology. Cuban (1986, 2001) argued that this is due to the fact that the emphasis placed on technology has given value to the technology whereas in the past, new innovations such as overhead projectors, ditto machines, and film projectors have been viewed as value-neutral. As a result teachers perceive the increased pressure to use technology as a judgment on their teaching. The notion that good teachers use technology and bad teachers do not use technology has caused resentment by teachers.

Frank, Zhao, and Borman (2004) argue that social capital processes related to the implementation of educational innovations are vital. This study investigated how social structure within six schools affected the implementation of computer technology by applying the theory of social capital that they operationalized as “the potential to access resources through social relations” (p.149).

The cultural context of an organization (school) often provides stability and influences the change process within an organization (Sergiovanni, 2000). The enduring and resilient nature of an organization's culture makes change difficult. A change in the procedures or direction of an organization often forces one to alter or discard traditional ways of doing things.

Fullan (1991; 1992; 1993, 2001) analyzes educational change. His conclusion is that projects designed to bring about educational reform or noteworthy change in the nation's educational system fail. In a nutshell, the reason for lack of sustainable change is that substantive educational reform requires a lasting change in all of the stakeholder groups, each of which may resist change in its own way. For example, policy makers may support educational reform as long as the effort raises test scores, teachers may support reform as long as it aligns with their beliefs about teaching and learning; but unless all stakeholders support the reform effort, the effort will fail. Fullan (2001) indicated, "Understanding the change process is less about innovation and more about innovativeness" (p. 31). In other words, whether an innovation is successfully diffused is more a matter of the organization's culture than the innovation itself. (House, 1974; Dooley, 1999)

To be able to integrate technology into the curriculum, teachers must possess a certain amount of technology literacy. Similarly, in order to learn with technology, students must possess an amount of technology literacy. The question of how technology should be integrated into the curriculum depends on how one defines literacy. The increasing emphasis on technology in education has prompted a new definition of what it means to be literate.

How is Literacy Being Redefined as a Result of Technology in Schools?

As technology becomes more and more ubiquitous in classrooms and in our society, the term *literacy* continues to evolve and change. We are in the midst of a historic transformation in which technology is redefining literacy (Coiro, 2005, Leu, 2000a; Reinking, 1998). Literacy was once limited to text-based or oral instruction. As means of communication have evolved with technology, literacy has evolved to include hypertext documents, multimedia projects, and online communication. Coiro (2005) explains that the changes may be categorized into four challenges for students: to search for, navigate, critically evaluate, and synthesize information. This redefinition holds the potential of making drastic changes in education and society.

The Internet has revolutionized how and with whom we communicate. Videoconferencing, instant messaging, email, blogs, and wikis are all methods of communicating with individuals in a disparate location. By changing the way information is absorbed, processed, and used, technology is influencing how people read, write, listen, and communicate (Holum & Gahala, 2001). Leu, Kizner, Coiro, and Cammack (2004) define the new literacy as:

The new literacies of the Internet and other ICTs include the skills, strategies, and dispositions necessary to successfully use and adapt to the rapidly changing information and communication technologies and contexts that continuously emerge in our world and influence all areas of our personal and professional lives. These new literacies allow us to use the Internet and other ICTs to identify important questions, locate information, critically evaluate the usefulness of that

information, synthesize information to answer those questions, and then communicate the answers to others (p. 1572).

The term *information literacy* was coined in 1974 (Behrens, 1994). Information literacy is the “set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information”(American Association of School Libraries, 1998). “In the information age or post-information age in which we live, literacy is essential to enable individuals, groups, and societies to access the best information in the shortest time to identify and solve the most important problems and then communicate this information to others”(Leu, 2000a; Leu, 2000b).

Recognizing the importance of social context Leu et al (2004) identified three social forces that frame literacy within the age of computers:

- global economic competition within economies based increasingly on the effective use of information and communication
- the rapid emergence of the Internet as a powerful new technology for information and communication
- public policy initiatives by governments around the world to ensure higher levels of literacy achievement including the use of the Internet and other ICTs (p. 1575)

The evolving meaning and definition of literacy has significant implications for educators.

Implications for Educators

NCATE mandates that teacher candidates should be “able to appropriately and effectively integrate technology and information literacy in instruction to support student

learning”(National Council for Accreditation of Teacher Education, 2001). Leu (2000b) takes this a step further when he calls for educators to respond to the evolving definition of technology, “We must begin to develop strategies to help each of us keep up with the continually changing definitions of literacy that will exist in our world” (p. 763).

Educators can no longer assume students will master information literacy skills in the context of learning traditional school subjects (Crouse & Kasbohm, 2004). Rather, information literacy skills must become a deliberate component of the school curriculum. Too often, teachers assume that because students are able to navigate Web pages or play and develop multimedia games, they have technology literacy skills. More often than not, however, students do not possess sufficient technology literacy skills to facilitate learning. The nature of information literacy skills calls for educators to rethink literacy in our schools. The new literacy skills in the 21st century include the ability to solve problems quickly by accessing information and communicating solutions (Harrison & Stephen, 1996). Leu (2000b) states, “It may become unimportant to demonstrate the advantages of new technologies for educational contexts if its already clear those technologies will define literacies of our students’ futures” (p. 762). Leu (2000b) presents a framework to help make sense of the technology and literacy’s interrelationship. His framework consists of the transformative, transactional, and deictic method of thinking about the relationships. The transformative perspective is based upon the notion that technology helps reshape literacy. According to the transactional view, technology and literacy shape one another. The deictic perspective incorporates both and emphasizes the constantly evolving forms and functions of literacy. Warschauer further explains this by stating, “Electronic literacy involves not only adapting our eyes to read from the screen

instead of the page, but also adapting our vision of the nature of literacy and the purposes of reading and writing”(Warschauer, 1999, p.13). Students must be able not only to locate appropriate information but also to critically read, analyze, evaluate, and make inference.

Reading on the Internet presents three distinct challenges (Schmar-Dobler, 2003). First, voluminous amounts of information are now available. Second, distracting graphics and animations often distract the reader, causing the reader to learn how to evaluate all aspects of a web page to decide which will be most helpful. Finally, the majority of text on the Internet is expository and hypertextual. Readers must have a familiarity with concepts, vocabulary, and format to best understand expository writing.

Hypertext documents are nonlinear and dynamic. Documents are written with embedded hyperlinks that give readers the freedom to read in a non-sequential fashion. For some, this offers a sense of individualized learning. For others, this presents a sense of disequilibrium that makes it difficult to comprehend the content. Landow (1992) purports that reading and writing in hypertext will bring about an entire paradigm shift. He believes that the paradigm shift brings the reader and writer to a higher level of human thinking and experience. Landow (1992) cites the liberating qualities of hypertext to be closely aligned with theorists such as Foucault, Derrida, Bakhtin, and Barthes,

Hypertext . . . has much in common with recent literary and critical theory. For example, like much recent work by poststructuralists, such as Roland Barthes and Jacques Derrida, hypertext reconceives conventional, long-held assumptions about authors and readers and the texts they write and read. Electronic linking, which provides one of the defining features of hypertext, also embodies Julia Kristeva's

notions of intertextuality, Mikhail Bakhtin's emphasis upon multiivocality, Michel Foucault's conceptions of networks of power, and Gilles Deleuze and Felix Guattari's ideas of rhizomatic, 'nomad thought.' The very idea of hypertextuality seems to have taken form at approximately the same time that poststructuralism developed, but their points of convergence have a closer relation than that of mere contingency, for both grow out of dissatisfaction with the related phenomena of the printed book and hierarchical thought. (p.1)

Paradigm shifts such as these must be examined through the lens of social context (Bruce, 1997). Bruce suggests that the cultural contexts of literacy and technology hold potential to transform our society. The impact of technology on our society is not unlike the impact the printing press had on 15th century society. The discovery of the printing press brought about a paradigm shift in the way information was organized and disseminated. As we investigate the links to the curriculum and the new paradigm shift, social and cultural impacts of technology emerge. To understand the impact of technology on schools, we next examine social and cultural impacts of technology in schools.

What are the Social and Cultural Impacts of Technology in Schools?

The review of the literature demonstrated that the impact of technology on schools is much broader than educational policy and curriculum integration. The literature reflects that the impact of technology encompasses societal and cultural aspects. Our society is in the midst of transitions that will be as far-reaching as the Industrial Revolution. The transitions propelled by technology are intertwined with education, politics, economics, and culture. The all-encompassing nature of technology diffusion is

referred to as technoculture. The proliferation of technology within society has far-reaching effects on social and cultural aspects of society. Despite these effects, the diffusion of technology has not occurred for all students in schools. There is a well-documented divide of technology access and usage within schools.

Digital Divide

The digital divide is a term often referred to as the “the gap between the technology *haves* and *have nots* “(Norris, 2001). It first became an educational issue in the 1980s when Apple computers entered the classroom. Within three years of having computers in the classroom, two-thirds of high income schools had computers while two-fifths of lower income schools had computers, making the gap between the technology *haves* and *have nots* obvious and apparent (Compaine, 2001) The digital divide can be used to discuss inequalities between individuals within a society or between developing or developed countries. For the purpose of exploring technology in U.S. schools, however, this discussion will be limited to the digital divide within the U.S. and the implications for education.

The National Telecommunications and Information Administration (NTIA) first reported on the digital divide in 1995, with their report, *Falling Through the Net: A Survey of the “Have Nots” in Rural and Urban America*. The term digital divide attracted mass media attention in 1998 when the NTIA used “digital divide” in the title of their second national survey (Compaine, 2001). The NTIA continued to publish reports in 1998, 1999, 2000, and 2004. Taken together, these reports implicitly tell a story of technological determinism: that technology is not so much revolutionary as it is

evolutionary, and that evolution is inevitable, inevitably progressive, and progressively desirable (Monroe, 2004).

Digital divide is typically based on ethnicity and socioeconomic status (Judge, Puckett, & Cabuk, 2004). Therefore access to computers and connectivity is often seen as a remedy to the digital divide. There are numerous reports that illustrate the obvious gaps in access and connectivity between the *haves* and *have nots* (Compaine, 2001; Judge et al., 2004; Norris, 2001). According to a 2000 report, approximately one-third of the U.S. population used the Internet at home; however, only 16.1 percent of Hispanics and 18.9 percent of African Americans used the Internet at home (U.S. Department of Commerce, 2002). As of 2002, these numbers had increased with one-half of the U.S. population using the Internet at home, and 37.6 percent of Hispanics and 39.8 percent of African Americans using the Internet at home (U.S. Department of Commerce, 2002). According to the latter report, family income continues to be an indicator of computer and Internet use at home.

NCES (2005) reports that K-12 students whose families were in poverty were less likely to use the Internet at their homes than K-12 students whose families were not in poverty (47 percent compared with 82 percent) (p.8). Minority children and children of low socioeconomic status are less likely to have a computer in their home (Judge et al., 2004; Wilhelm, Carmen, & Reynolds, 2002). Thereby, children and adolescents whose parents have at least some graduate education and whose families have incomes of \$75,000 or more per year are more prone to use computers at home (NCES, 2005). The NTIA (2000) report concludes:

Internet access is no longer a luxury item, but a resource used by many. Overall, the findings in this report show that there has been tremendous progress in just 20 months, but much work remains to be done. Computer ownership and Internet access rates are rapidly rising nationwide and for almost all groups. Nonetheless, there are still sectors of Americans that are not adequately digitally connected. Until everyone has access to new technology tools, we must continue to take steps to expand access to these information resources. (p. i)

Despite the many reports that illustrate the blatant gaps between the *haves* and *have nots*, there are other reports that demonstrate that the gap is narrowing. The U.S. Department of Commerce study *A Nation Online: How Americans Are Expanding Their Use Of The Internet*, reported that Internet use by the lowest income households (those earning less than \$15,000 per year) increased by more than twice the rate of the highest income households (those earning more than \$75,000 per year) from 1998 to 2001 (U.S. Department of Commerce, 2002) The study also found that African Americans and Hispanics' Internet use increased 30 to 33 percent, a rate higher than the annual rate for Caucasians.

African American children with a computer at home grew from 24 percent in 1997 to 46 percent in 2001. Hispanic children's home access increased from 23 percent in 1997 to 47 percent in 2001. In 2001, 50 percent of non-Hispanic white children had Internet connectivity at home, while only 25 percent of African American children and 20 percent of Hispanic children had home Internet connectivity (Wilhelm et al., 2002). The U.S. Census Bureau (2003) found that 79.1 percent of Americans have access to the Internet either at home or at work.

Using reports such as these, the U.S. Department of Commerce and others purport that the digital divide no longer exists and is not a societal issue (Jackson et al., 2003). The gap between access and connectivity may indeed be shrinking, resulting in a narrowing of the digital divide when it comes to access and connectivity. However, access and connectivity alone will not resolve the underlying issues surrounding the digital divide. Despite the progress we have made in closing gaps of access and connectivity, approximately fifty percent of adults are still “disconnected” at home (Jackson et al, 2003). Access is dependent on socioeconomic status, gender, race, age, and place of residence, and how an individual uses the computer. For example, better educated individuals are more prone to use the computer for tasks related to work, education as well as political and social engagement (Robinson, DiMaggio, & Hargittai, 2003).

Jackson et al. (2003) found that throughout history, race and age were the only predictors of Internet use. Their study found that African Americans and older participants used the Internet less than Caucasian participants and younger participants. Jackson et al. (2003) offers three explanations for why African Americans use the computers less than Caucasian Americans, when access is not an issue: cultural differences in preferred communication modalities and partners, lack of individuals to engage in online communication, aesthetic preferences and web design, high need for technical support. The results of the study emphasize the need to further study cultural factors as they related to use of technology,

Suggests that a reconceptualization of the digital divide that focuses on race rather than access may be helpful in distributing the benefits of technology to all. Such a

reconceptualization directs research attention to cultural factors that influence the extent and nature of technology use. (p. 157)

Recognizing that the digital divide is about more than access we are prompted to consider digital equity. Digital equity refers to equitable access to computers and connectivity and to culturally relevant technology (Judge et al., 2004). Digital equity embraces the principles of social justice to see that not only does everyone have access to technology, but that they have skills to use the technology, and that the means and materials are culturally relevant.

The National Institute for Community Innovations identified five dimensions of digital equity: content creation, effective use, quality content, cultural relevance, and technology resources (National Institute for Community Innovations, 2001). It is imperative that educators go beyond the issue of access and consider the dimensions of digital equity. Otherwise, access to technology could intentionally or unintentionally continue to further promote social inequity.

Implications for Teaching and Learning

The implications of the digital divide and digital equity for teaching and learning are severe. Schools are an entry point to developing technology skills for most children, despite the increase of home computers. This entry point is even more significant for low poverty children (Judge et al., 2004).

Recent federal initiatives such as the 1994 Elementary and Secondary Education Act, E-Rate Initiative, and No Child Left Behind Act all include digital equity as one of their objectives (Judge et al, 2004). Schools and communities across the country have

implemented projects to combat issues related to the digital divide and digital equity. Online learning offers a variety of models of combating these issues. Learning online allows students to engage in learning experience across great distances. Virtual schools and online classes provide students more equitable access to enroll in coursework not available in their own school. Online initiatives such as the ESTRELLA initiative provide laptops to migrant farm worker families. Children of migrant farm workers are then able to keep up with school work online while the families migrate with their families during farming seasons (Kinser, Pessin, & Meyertholen, 2001).

Handhelds offer another initiative schools are investigating to overcome the digital divide. Handhelds and their accompanying wireless connectivity are exponentially less expensive than traditional school computers and networks. Bull, Bull, Garofalo & Harris (2002) refer to these technologies as “low-power, low-cost” technologies that will remove the issue of access. Portable computer devices that are affordable for schools may soon be on the horizon. MIT recently developed a \$100 laptop specifically developed for schools in developing countries and Novatim is designing a home computer that will be marketed for \$75 (Bull & Garofalo, 2006). Initiatives such as these seek to tackle the access issue with affordable options for students.

The digital divide and the efforts to combat the disparity leads us to examine implications for education. Access is not the magical solution to the digital divide issue. Research studies have shown that equal access does not necessarily result in equal technology applications. Even when there is equal access, teachers of poor and minority students typically use low-level approaches of technology (Cuban, Kirkpatrick, & Peck, 2001; Ganesh & Middleton, 2006; Zhao & Frank, 2003) . Poorer students are shown the

least effective ways to use technology for learning. Pedagogical methods used most often with minority students are grounded in behaviorist theories of learning (Healey, 1998).

Researchers are beginning to report on studies in which technology can add to the development of culturally diverse learning community, deepen meaningful discussion of controversial and sensitive issues such as prejudice, privilege, and discrimination and increase educational equity by changing patterns of dominance and interaction (Merryfield, 2000).

Instead of selling the economic benefits of connectivity, we should speak more pointedly – and could do so in much better faith – about the educational benefits of interconnectivity between students, between classes, between schools, and between schools and universities. Such connections crisscross the digital divide, bringing the underprivileged and the overprivileged in contact, not just as individuals, but as groups, communities, and institutions. (Monroe, 2004, p. 29)

Therefore, digital equity means not only access, but also teachers who have the skills and knowledge to effectively integrate technology into teaching and learning. It is apparent that the digital divide involves strong issues of social networking, formations of new forms of affiliating, and new means of networking to organize social, economic and political actions (Mason & Hacker, 2003). The gap transcends schools and is a mirror of the existing divide between rich and poor in our society. The divide is “at once economic, racial, discursive, and epistemological in character” (Monroe, 2004, p.84).

Technology holds the ability of maintaining status quo in our society. It could be used to continue to funnel power to the *haves* while restricting power of the *have nots*. Or, technology holds the potential of giving voice and power to the disenfranchised. The

notion of digital equity calls for educators to develop a “pedagogy that can kindle critical consciousness” (Monroe, 2004, p. 84).

Summary

This review has shown the tremendous increases in access and availability of technology in our schools and society. Nearly all of the nation’s K-12 public schools have computers and Internet access located on the school site and technology integration continues to capture the attention of educational scholars. This review has problematized the current realities that the promise of widespread educational and cultural reform resulting from technology integration has yet to be fulfilled; systemic and sustainable technology integration has not yet occurred. This is due, primarily, to the traditional nature of schools and schooling in America and to societal issues.

Technology has led to a redefinition of literacy. Additionally, educators and scholars are attending to issues of digital equity, the digital divide, and technology integration into curriculum. The research community has provided empirical evidence that technology integration can benefit students and can impact reform efforts. As educators prepare students to manage technology in socially just ways and as researchers focus attention on equity issues related to technology integration, students and society will reap the rewards.

The number of computers in K-12 schools has grown significantly since the mid-1980s; they have become pervasive throughout society and technology continues to change rapidly. However, the change within K-12 schools has been slow. Often times useful and beneficial innovations are not adopted. Diffusion theory can help us better understand this phenomenon.

Diffusion Theory

Diffusion theory (Rogers, 1995) provides a framework for understanding the impact that technology has had on schools and schooling. This theory allows for technology to be considered an *innovation*, “defined as an idea, practice or object that is perceived as new by an individual of another unit of adoption” (p.xvii). The process of diffusion begins with the introduction of an innovation and ends with its adoption or rejection. The characteristics of the innovation influence the rate of adoption and include its perceived relative advantage over existing technologies/ideas, its compatibility with the individual or organization, how clearly the innovation can be understood, how easily it can be communicated and how easily the innovation can be tried or experimented with.

Individuals in a social system, in this case schools, do not adopt an innovation at the same rate but, rather, in an over-time sequence. Therefore, individuals and institutions can be classified into *adopter categories* such as innovators, early adopters, early majority, late majority and laggards (Rogers, 1995, p.255). For example, the ACOT study (Sandholtz, Ringstaff & Dwyer, 1997) and its researchers/innovators set a vision for the early majority of adopters that followed.

The findings in this review indicate that the majority of the research literature on technology and schooling focuses on innovators, early adopters and opinion leaders. According to Rogers (1995), an opinion leader is able to influence other’s attitudes or overt behavior informally in a desired way with relative frequency (p.27); an innovator is venturesome and develops communication patterns and relationships among a clique of innovators (p.263). Diffusion theory provides a lens through which to identify the factors that hinder or facilitate technology integration such as adopter characteristics and

technological characteristics. The following sections will address the key findings from this review and provide an analysis of these findings within the context of diffusion theory.

Historical

According to Rogers (1995) diffusion is a type of social change, defined as the process by which alteration occurs in the structure and function of a social system. The researchers in the 1960s and 1970s (for example, Papert, 1978, 1980; Pea, 1983; Thornburg, 1984) can be considered innovators. These scholars were among a camp whose vision for educational technology was educational transformation.

The educators involved in the ACOT study (Sandholtz, Ringstaff & Dwyer, 1997), under diffusion theory, can be considered influential opinion leaders in regards to technology in schools. As this review has suggested, the results of this study have left an imprint on the educational technology field. Opinion leaders and change agents provide information and advice about innovations to others within the educational system. The researchers involved in the ACOT study were pivotal in setting forth new possibilities for technology and schooling.

Policy and Legislation

The *Preparing Tomorrow's Teachers to Use Technology* (PT3) grants provide an example of various diffusion categories. Three levels of PT3 grants were available: (a) Catalyst grants were intended to stimulate large-scale innovative improvements for teacher preparation and were generally awarded to *opinion leader* organizations, (b) Implementation grants were intended to engage consortia in systemic reform of teacher

preparation and were typically awarded to *early adopter* organizations, and (c) Capacity-building grants were intended to lay the initial groundwork for technology integration and teacher preparation reform and were awarded to *early majority* organizations. For example, the International Society for Technology in Education (ISTE) developed the National Education Technology Standards (NETS) with the Catalyst grant; California State University Sacramento developed and implemented a professional development model for technology integration with one of their school district partners with the Capacity-building grant. The influence of the federal government supported initial diffusion of hardware in U.S. public school classrooms by acting as a change agent (Rogers, 1995) thereby influencing innovation-decisions in a direction that the federal government deemed desirable.

Curriculum and Pedagogy

The field of technology integration in curriculum and pedagogical issues is vast. As stated previously, the extant literature indicates that, to some extent, technology is being used in ways that correlate with the ACOT vision as well as in ways that the educational community may consider traditional. In light of this, diffusion theory can help us understand why the effects of technology have not been pervasive within the culture of teaching and learning.

Standards

The *NET Standards for Teachers* (ISTE, 2002, 2008) and the *NET Standards for Students* (ISTE, 2000, 2007) exert some influence other's attitudes or overt behavior; hence, the purpose of standards. The adoption of the *NETS* by NCATE and the resulting impact upon teacher education programs has been significant, and ISTE remains an

opinion leader. There is a dearth of literature that informs us as to the K-12 classroom impact of these adoptions.

Several educational institutions within the United States can be considered “innovators or opinion leaders” (Hofer, 2003). The teacher preparation programs that have received the ISTE NETS Distinguished Achievement Award for implementation of NETS can be considered opinion leaders as well (Cunningham, 2003; Hofer, 2003; Wetzel, Zambo & Padgett, 2001). Within this framework, the abundance of extant doctoral dissertations from these institutions addressing technology in schools can be explained. The faculty as well as the institutions may be considered opinion leaders that place emphasis on technology integration. For example, a university may house a Center for Technology that, in turn, may fund graduate students resulting in technology focused research.

The gap between vision and reality exists because diffusion has not yet occurred. The adoption of the innovation has not been diffused beyond innovators, early adopters and perhaps a portion of the early majority. There is little to no evidence in the extant literature that the diffusion of technology has occurred beyond the innovator and early adopter stages (Rogers, 1995).

However, diffusion theory does allow for further diffusion to occur in the coming decades perhaps much like other educational innovations such as small-group teaching, reading and mathematics innovations, in which teachers altered their fundamental classroom practices. Early adopters and opinion leaders are often the “embodiment of successful, discrete use of new ideas” (Rogers, 1995, p.264) and not considered

“traditionalists” and later adopters often deliberate for some time before adopting a new idea or innovation.

Social and cultural

At the risk of oversimplifying, diffusion theory can help problematize the digital divide and digital equity. Innovators and early adopters; hence, opinion leaders, often have control of substantial financial resources and access to innovations. Without necessary resources, the disparity between the *haves* and the *have nots* persists.

Mason and Hacker (2003) explore diffusion theory for understanding the digital divide. Diffusion Theory is based on the notion that new technology adoption follows an S-curve and those with more resources adopt innovative technologies first (Rogers, 1995). That is technology is not adopted by everyone at the same time, but over time adoption by the masses occurs. If this theory is accepted, then the digital divide issue will supposedly remedy itself over time (Bull et al., 2002).

The Apple II computer introduced in the 1970s had computing capacity equivalent to that of the mainframe computer in mission control that guided Apollo 11 to the first moon landing in 1969. Similarly, today’s Pam M100 handheld computer has about 200 times more memory capacity than the Apple II at 1/20th the cost. Based on these trend lines, we can predict with reasonable certainty that the majority of students in the public schools will have a wireless device by the end of the decade or sooner (Bull et al, 2002, p. 7).

If we consider implications for education and the digital divide through the lens of Diffusion Theory, we must recognize that as technology skills evolve over time, the specific technologies needed to overcome the digital divide is a “moving target”

(Compaine, 2001). For example, it was unheard of for teachers and students to possess web-authoring skills fifteen years ago. Yet, today with the ease of web authoring software, many teachers and students possess this skill.

Along with skills changing over time, hardware, software, and network requirements change over time. The technology has evolved over time from initially being computer ownership, to Internet connectivity, to high speed connectivity (Compaine, 2001). It changes so much so that today, digital divide is synonymous with the access issue (Monroe, 2004).

Bull et al (2002) purport that the hardware digital divide is a temporary phenomenon. They state that the future divide will not be about who has access, but rather who knows what to do with the technology. They call this divide a *didactic digital divide*. In this situation, educators continue to move forward with emerging technologies, knowing that the *have nots* will catch up, yet, at the same time adding an emphasis on pedagogy and application.

Research Critique

This review synthesized literature in which technology innovation and technology integration into K-12 schools has been the focus. Over 700 potential sources were reviewed as a part of this synthesis. The review demonstrated that the field has significant limitations. Recognizing these limitations almost ten years ago, the Panel on Educational Technology of the President's Committee of Advisors on Science and Technology (President's Committee on Advisors on Science and Technology, 1997) called for "a large scale program of rigorous, systemic research on education in general and educational technology in particular will ultimately prove necessary to ensure both the

efficiency and cost-effectiveness of technology use within our nation's schools" (p.7).

Since that time, extraordinary amounts of money have been spent on educational technology efforts in our nation's schools. Yet, this review of the literature has revealed that we still know relatively little about the impacts and consequences of integrating technology into our schools.

The U.S. Department of Education's report, *A Retrospective on Twenty Years of Education Technology Policy* (Culp, Honey, & Mandinach, 2003) emphasized this point when it reported, "The call for research on the impact of educational technology on schools and teaching and learning activities is a final constant theme found over the past twenty years of reports" (p. 15). Roblyer and Knezek (2003) further resounded the call for a new education technology research agenda by contextualizing technology research within the current political climate

The need for a new research agenda has never been more urgent. Recent projects under the U.S. Department's (DOE) *Preparing Tomorrow's Teachers to use Technology PT3* initiative have demonstrated clearly that the process of integrating technology effectively comes with a high price tag...The DOE's National Technology Plan could be the single most influential force on educational technology research agenda for the future. It is crucial that the important topics to be studied are articulated now and offered as an integral part of the plan. (p. 63)

As discussed earlier, the field is restrained by the limited number of large-scale quantitative studies and by the large number of qualitative studies that focus on small populations. The synthesis of the literature provided in this review demonstrates

disjointed efforts to investigate the impact of technology on learning in schools that are also ungrounded in theory. The lack of a common research agenda is due to three unique characteristics to the field: the relative newness of technology in schools, the rapidly changing nature of the field, and the fact that educational technology research is conducted by a variety of stakeholders without a focus on student learning.

There are signs, however, that the field is attempting to defragment itself and develop a common research agenda. Like most fields of educational research, educational technology research is struggling to redefine itself in the wake of the *No Child Left Behind Act of 2001 (NCLB)*. As called for by NCLB, scientifically-based research requires researchers to rethink their research designs. One of the driving purposes behind the Federal Government's efforts is to encourage research that directly impacts student learning and teaching methods. Berliner (2002) refers to the difficult job educational researchers are facing today by commenting,

Easy-to-do science is what those in physics, chemistry, geology, and some other fields do. Hard-to-do science is what the social scientists do and, in particular, it is what we educational researchers do. In my estimation, we have the hardest to do science of them all. . . We face particular problems and must deal with local conditions that limit generalizations and theory-building – problems that are different from those faces by the easier-to-do sciences. (p. 18)

Roblyer (2005) contends that educational technology researchers have an unusually difficult time following new federal research guidelines because technology tools changes so rapidly that it is nearly impossible to build a body of literature on a tool over time. She also claims that the research paradigm to compare learning with

technology against learning without technology is often made complex by instructional design and teacher-effects. Harris (2005) supports the notion that educational technology research has been slow to show significant results. Harris claims the reasoning behind this is that field does not have a focused agenda. She purports that the field is divided between those who see technology as a “technocentric” approach to education and those who see education technology research as pedagogical dogmatism. The technocentric approach is one in which the focus is on the technology tools. Harris argues that this approach has filled the literature with fragmented and meaningless studies. She cites Zhao et al (2002) who discusses the disconnect,

Traditionally, studies on educational technology have been largely interested in finding out, in horserace fashion, the relative success of particular technological innovations as it affects student learning...Because many of these technology-specific studies did not explore more fundamental issues in technology and education...the research community is having a difficult time offering desperately needed suggestions to policy makers and practitioners. (p. 483)

Harris continues by claiming that the second approach that has weakened educational technology research is pedagogical dogmatism. She refers to the field’s efforts to reform schools through technology as the “Trojan horse” agenda. Too often, researchers have attempted to use technology to mask motives to transform teaching and learning. Harris (2005) recognizes that many technology leaders define their work with constructivist theories. She urges the field to consider “whether professional, political, or personal penchants should dictate large-scale educational policy – especially those in democratic societies (p. 119).

Cuban (2001) argued that “champions of technology wanted *fundamental* change in classroom practice” (p.135), and that only incremental changes have resulted due to technology use and referred to technology as *oversold and underused*.

To fervent advocates of using technology in schools, no revolution had occurred in how the teachers organize or teach in these classrooms. Nor have there been dramatic or substantial changes in how teachers teach or children learn. If anything, the addition of a computer center to the array of centers already in common use in these classrooms means that teachers have adapted an innovation to existing ways of teaching and learning that have dominated early childhood education for decades. (p.58)

Recognizing the field’s fragmented research focus, the editors of six leading educational technology journals recently called for a proactive research agenda for the field of educational technology (Bull et al., 2005). The editors lamented, “the body of usable information available today is scant and scattered” (p.218). They purport that the lack of a common research agenda is due to unrealistic expectations for technology-based reform, lack of consensus on research questions and methodologies, and the diminished role of research in school reform. “To date there have been no documented systemic increases in student achievement and learning directly attributable to technological innovation” (Bull et al., 2005, p. 218). A proactive research agenda would foster a collaborative partnership between educators and research. This partnership would help to better connect educators and the research questions they pursue with researchers and the questions they pursue (Bull et al, 2005).

Means and Haertzel (2003) likewise call for innovative research and cite that “multiple and complementary research strategies are needed to measure the implementation and impacts of learning technologies, no single study, genre of studies, or methodology is adequate to the task (p.257). Means and Haertzel (2003) call for three specific strategies of research designs:

- Contextualized evaluations, which focus on studying the context within which an innovation is implemented and the way the innovation unfolds with a complex organizational system
- Multilevel, longitudinal research, which uses statistical models to estimate (1) the multiple contexts of students’ learning environments, (2) the innovation’s cumulative effects, and (3) the direct and indirect effects of contextual variables on outcomes and implementation
- Random-assigned experiments, in which students, classes, or schools are assigned at random to participate in a particular treatment or in a non-treatment control group. (p. 258)

The field of educational technology research is at a significant crossroads. This is a time that the field can choose not only how to respond to mandates such as those outlined in NCLB, but the field can choose how to chart its future within the lives of schools. It is a reality that the literature has not clearly documented that technology has impacted teaching and learning (Roblyer & Knezek, 2003). Schrum et al (2005) call for the field to “create a strategy that simultaneously meets the requirements for evidence that technology can make a difference in classrooms and articulates what we understand to be essential in asking appropriate questions and designing authentic research” (p. 204).

They continue by emphasizing the importance to connect teacher beliefs, teacher practices, and subsequent student learning outcomes.

Following the standards discussed above would enhance future research. The authors also recommend that the field needs more theory-driven research. Burkhardt and Schoenfield (2003) recognize the need for theory-driven research. They purport the lack of theory is parallel to the lack of a clear rationale.

Lack of attention to coherent theory building leaves us looking balkanized and incoherent...It also leaves us vulnerable to attack from the outside – powerful politicians, and some academics, who understand little of what educational research is all about feel empowered to tell us how to go about our business.

(p.13)

Designing theory-driven studies encourages researchers to build on existing findings and show connections among studies. Recognizing the unique nature of educational technology research within the current climate, we offer the following questions as suggested future research:

- How has technology integration affected learning outcomes?
- What measurement tools are best suited to the new schools and strategies that technologies require?
- What are the educational implications of technology research being conducted outside of the field of education (i.e. economics, business, sociology, information sciences and psychology)?
- What factors influence and perpetuate digital equity? What are the effects of technology on social interaction and collaboration within learning environments?

- What evidence is needed to indicate that diffusion of this innovation has occurred?

New Model for Technology Integration

Recognizing the current status of technology in teaching and learning, we have developed a model of technology integration to frame future efforts to investigate and document technology in schools. The model is situated within the literature presented in this review and presents educators and researchers with a new lens to examine technology in schools. There are four factors within this model: technology agenda, research models, diffusion of innovation, and technoculture. The figure below represents how these factors are interrelated.

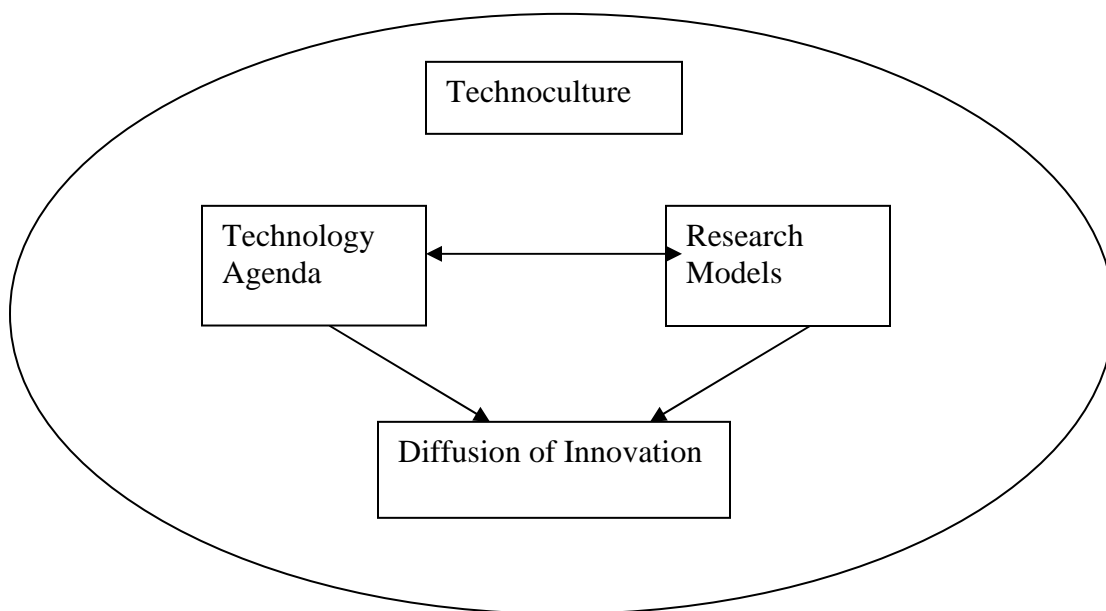


Figure #1 Model for Technology Integration

The field must recognize that the tension between technocentrism and pedagogical dogmatism are one cause for disjointed efforts to integrate technology in schools and for fragmented research agendas. It is time for the field to make a decision as to overtly use technology to promote school reform or to promote technology innovation throughout the existing school curriculum (Harris, 2005). We believe that educators and researchers should recognize this and place value on “pedagogical plurality” (Harris, 2005). Making this choice not only presents a new schema for technology integration, it also presents a new lens for technology research.

The new model for technology research should be expanded to clearly convey the essential role technology is playing in our society and in our schools to create a technoculture. The new model of technology research should connect teacher beliefs, teacher practice, and student learning outcomes (Schrum et al., 2005). The field is not only limited in these three areas, but we know little about how these three are connected.

Framing technology as a learning tool encompasses each of these three factors. Technology is a tool that should be examined within the context of larger societal structures (Berson, Lee, & Stuckart, 2001). Postman (1998) reminds society “culture always pays a price for technology” (p.3). The technoculture created by the proliferation of technology in our society, places technology in a distinctive position. It is not just an innovation being implemented in classrooms. Technology is firmly entrenched in our society. The life students live outside the classroom is inundated with technology. Research efforts cannot be limited to technology within classrooms. To fully grasp the technology’s impacts, researchers must consider how technology impacts culture and society.

Education researchers should also examine research conducted in other academic fields. Given that the field of library science prepares school media specialists and supports research that examines uses of media and technology, library science has a natural connection to the field of education. The American Association of School Librarians (AASL) president supported the notion that the fields of education and library science should collaborate when she stated,

As tech-savvy leaders, school library media specialists ...are partners in the school community - budgeting innovatively, improving teacher's knowledge and skills through technology training, supporting e-learning, and using technology to provide equitable access to all members of the school community (Vaughn, 2005).

Library science research offers the field of education insight into student learning with technology. Specifically, recent efforts into constructing digital libraries and learning with digital libraries offer valuable information for educators. Education researchers should also seek out relevant research from the business field. Specifically, the field of education could inform its work by examining organizational theory and research from the business field. Business organizations have arranged themselves to reflect the changes technology has on the way we live and work. Schools have been slow to arrange themselves to reflect the changes technology has on the way we live and learn.

The impact technoculture has on schools and learning is all encompassing within the new model. It directly relates to technology agendas, research models, and diffusion of innovation. Policy makers, educators, and scholars are all stakeholders in the field of technology integration. Each group has their own technology agendas that impact what

technology is integrated into schools and how it is integrated. This review has demonstrated the tremendous impact policy, legislation, funding, and standards have on the integration of technology. This model calls for stakeholders to join together and develop a common agenda for meeting the vision for technology integration. Harris (2005) takes the field to task when she calls upon researchers to determine whether they are pushing an agenda of technocentrism or pedagogical dogmatism. The review of the literature presented demonstrates that technocentrism does not advance the field. Researchers must heed the calls for future research discussed earlier and focus efforts on students and learning. Research focused on students and learning will not only help to defragment the field, it will help to move the field forward with a common focus. Otherwise, as demonstrated in this review, the field remains an every-moving target with few research findings that build on one another.

Complimentary to a common technology agenda are research models that investigate pedagogical issues related to technology integration. Research design should seek to investigate effectiveness of technology agendas. Oppenheimer's (1997) cornerstone critique of the field questions funding for technology in schools based on no "good evidence that most uses of computers significantly improve teaching and learning" (p.48). Unfortunately, the field has not significantly responded to the critique and there remains scant evidence to serve as a rebuttal to Oppenheimer. Research should be proactive and seek to move the field forward, "If technology is to be viewed as having a clear and essential role to play in education, it must have a clearly articulated research agenda and high quality studies that both document and shape its impact" (Roblyer, 2005, p. 199).

Research agendas that address these characteristics and address the contextual factors of the K-12 schools are pivotal for diffusion to occur. Longitudinal and widespread data is much needed. Contextual factors of K-12 schools do not allow schools to adopt innovations that do not meet their needs and support their goals. A focused research agenda that goes beyond the limitations of case studies, doctoral dissertations, and project evaluation is needed by K-12 schools; simply put, schools need the research that only the research community can provide.

A common agenda and solid research design will directly impact the diffusion of technological innovation. The educational research community can assist the diffusion process. Organizations (K-12 schools) adopt innovations when the innovation is perceived to be beneficial, is compatible with the goals of the organization, is clearly understood, and is easily used and accessible. Rogers (1995) claims there are five stages of adoption: awareness, interest, evaluation, trial, and adoption. The review of the literature clearly demonstrates that there is an awareness and interest by policymakers, students, and educators in the diffusion of integration of technology in schools. There have been fragmented interests in evaluation in the past. Evaluation of technology in schools has been limited primarily to small research studies that do not have a common agenda. As discussed earlier, leaders in the field are attempting to develop an evaluation agenda that is less fragmented and that produces more thoughtful and theoretically based findings. These findings would most likely lead to a more informed trial and adoption phase in which educators and policy makers can best decide which technologies to use in classrooms and how to use the technologies.

Summary

As stated earlier, the process of diffusion begins with the introduction of an innovation and ends with its adoption or rejection and occurs in an over-time sequence. The process of diffusion of technology remains in its early stages. The diffusion of the innovation during the last two decades of the twentieth century primarily included the innovators and early adopters. This early acceptance of the innovation provided the impetus for technology in K-12 schools and provided a fertile field for researchers who may also be categorized as innovators and early adopters; however, diffusion has not occurred beyond the two initial adopter categories in K-12 schools or in the research community. The early majority, late majority and laggards have not yet adopted the innovation. With a more focused research agenda, it is available for diffusion of technology to occur within all categories.

The impact of technology on the field of education has grown exponentially since the mid 1980s. Unquestionably, as technologies continue to emerge the impact will continue to grow. Moore's Law predicts that technology becomes more efficient every eighteen months. This translates into a handheld computer that costing \$300 today will cost \$150 in 18 months and \$75 in three years (Bull, Knezek, & Roblyer, 2005). Technology will continue to become more ubiquitous in society and continue to have consequences for schools and society. The implications are clear that educators must understand the degree to which technology is impacting policy and legislation, the culture of the school, and teaching and learning in the classroom.

Educators should take a proactive stance to embrace technology that allows them to live and learn in ways that are better than they could before they had the technology.

Educators should critically examine the new technologies to understand how technology impacts society and culture and to identify ways in which technology can be used to overcome patterns of injustice. Doing this requires collaborative efforts among educators, researchers, policymakers, and representatives from the technology field. In particular, research should be used to not only evaluate technology but also to guide future development and implementation.

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