Literature Review
Educational Technology

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LITERATURE REVIEW
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At A Glance

There is a growing consensus among educators and the general public that technology should play a more integral role in students' education. However, the question of whether the introduction of technology into the classroom has a positive impact on teaching and learning is still under intense debate within the educational community. This Literature Review discusses the advantages and disadvantages of integrating technology into the curriculum and provides strategies researchers have concluded contribute to the success of technology programs. Research conducted on technology programs is reviewed. Although these studies have produced inconsistent findings, they do suggest that the types of activities students engage in are more important than the frequency with which they use computers. Finally, the status of educational technology in Miami-Dade County Public Schools and statewide is summarized.

Over the past 20 years, technology has transformed society and changed many aspects of daily life. The proliferation of technology has led to a growing consensus among educators and the general public that it should play a more integral role in students' education (Culp et al., 2003; CEO Forum on Education and Technology, 2001; Fouts, 2000; Johnson, 2000). Schools' use of educational technology has continued to steadily increase over the years, as educators introduce a variety of efforts to integrate technology into the curriculum. In 2003, only 4 percent of U.S. school districts had implemented one-to-one computer programs (in which each student was given a computer for his or her own use). By 2006, more than 24 percent of school districts were in the process of transitioning to one-to-one programs. In 2006, the *America's Digital Schools* report estimated that over 19 percent of all student devices were mobile and predicted that this percent would increase to 52 percent by 2011 (The Greaves Group, 2006). In 2008, there were, on average, 3.8 students for every instructional computer in the nation's public schools, compared to 5.7 students per computer in 1999, and 125 students per computer in 1983 (Education Week, 2008; Glennan & Melmed, 1996).

Educational technology is not restricted to individual computer use. It can involve other equipment and applications, such as videoconferencing, digital television (allowing students to interact with programs at their own pace), electronic whiteboards, and digital cameras (Jackson, 2008; Education Week, 2007; McCampbell, 2002; Marshall, 2002). Educators have struggled with decisions regarding what types of technology to use and how to use them (Culp et al., 2003). Researchers agree there is not one "right" type of technology or one "right" way to use it; rather, it should match schools' learning and teaching goals and be appropriate for the students who use it (Sivin-Kachala & Bialo, 2000).

Districts and schools implement technology initiatives for different reasons. Program goals include increasing students' economic competitiveness, reducing inequities in access to computers, raising student achievement, increasing student engagement, creating a more active learning environment, and making it easier to differentiate instruction according to students' needs (Bonifaz & Zucker, 2004).

Each technology is likely to play a different role in students' learning. For example, word processing and e-mail can improve communication skills; database and spreadsheet programs can enhance organizational skills; and modeling software often increases understanding of math and science concepts (Honey et al., 2005). Experts have suggested that technology can enhance learning by providing students with the following opportunities (Honey et al., 2005; Gahala, 2001; Fouts, 2000; Johnston, 2000; Means, 2000):

- drilling and practicing with increasingly difficult content;
- accessing a wide variety of information and gaining knowledge from many sources;
- visualizing difficult to understand concepts;
- interacting with data, engaging in hands-on learning, and receiving feedback; and
- managing information, solving problems, and producing sophisticated products using tools such as spreadsheets, databases, and word processors.

Apple Computer (2005) examined trends in students' use of technology. They reviewed 30 studies on educational technology programs and concluded that students used laptops primarily for writing, taking notes, completing homework assignments, organizing their work, communicating with peers and teachers, and researching topics on the Internet. They tended to use word processing software, web browsers, and e-mail to accomplish these tasks. Those students who used their laptops to complete more complex projects were most likely to use design and multimedia tools, such as presentation software and software for making and editing digital images and movies.

Advantages and Disadvantages of Technology

Proponents of educational technology contend that technology accommodates individual learning rates and styles and offers access to learning at any time and in any location. They believe that the use of technology in the classroom provides students with the opportunity to (Jobe & Peck, 2008; Bebell, 2005; Honey et al., 2005; Waddoups, 2004; Gahala, 2001; Healey, 2001):

- acquire the technological skills they will need for future employment;
- develop critical thinking, problem-solving, and communication skills;
- collaborate with peers;
- engage in hands-on learning activities; and
- receive immediate feedback.

Advocates also claim that teachers benefit from the introduction of technology into the classroom. Technology gives teachers the ability to tailor instructional materials and assessments to directly address their students' learning needs; offers access to more authentic material to assist in the development and delivery of lessons; and provides additional sources of information for their students to draw upon in the classroom (Dunleavy et al., 2007; Waddoups, 2004; Healey, 2001).

On the other hand, critics list a host of reasons why technology should not be emphasized in schools (Dunleavy et all, 2007; Valdez, 2005; Jackson, 2004; Cooley, 2001; Northwest Regional Educational Laboratory, 2001; Wright, 2001; Blumenfeld et al., 2000; Weiner, 2000; Oppenheimer, 1997). For example, they contend:

- Some educators have endorsed technology indiscriminately, as if the use of computers automatically produces quality teaching and learning experiences.
- Too many schools emphasize technology over learning. For example, the ability to create an attractive document doesn't mean that students have a greater understanding of concepts in the core academic areas.
- When spending on technology increases, spending on other important programs and activities (such as art, music, sports, and field trips) decreases.
- Technology is not as cost effective as other interventions because equipment requires extensive support.
- Technological innovations have often proven unusable because schools lack the capacity to link equipment use with instructional objectives.
- The use of technology requires teachers with strong classroom management skills. Teachers must carefully monitor students' use of equipment and often have to provide complicated procedural explanations.
- Computers reduce students' opportunities for socialization.

- Some teachers use computers to entertain students with irrelevant activities.
- Children are at particular risk of physical problems, such as repetitive stress injuries or eye strain.

Some school districts have terminated technology programs following logistical and technical problems, resistance from teachers, and increasing maintenance costs. Liverpool Central School District (outside Syracuse, NY) eliminated its laptop program, claiming the machines had been abused by students, did not fit into its lesson plans, and had little impact on students' grades and test scores. Matoaca High School in Virginia began phasing out its laptop program when their students did not achieve greater academic gains than those without laptops. In 2005, Broward County Public Schools cancelled a plan to provide laptops to all of their students after evaluating the costs of a pilot program. The district spent $7.2 million to lease 6,000 laptops for four pilot schools and was charged over $100,000 for repairs not covered by warranties. District officials concluded that a one-to-one initiative was not cost effective (Hu, 2007).

Strategies that Contribute to Technology Programs' Success

The introduction of technology into the classroom doesn't automatically translate into better instructional outcomes. Research has demonstrated that the manner in which technology programs are implemented is equally, if not more, important than the type of technology used. Studies have found that the least effective technology programs were those that simply placed hardware in classrooms, with little or no regard for the integration of the technology into the curriculum, issues of equity, or the provision of teacher support (Valdez, 2005; Barrios et al., 2004; Marshall, 2002; Fouts, 2000; Sivin-Kachala & Bialo, 2000). Many factors influence the level of a program's effectiveness, such as the extent to which teachers are trained and prepared to implement the program, the level of student access to the technology, and the provision of adequate technical support. In other words, school districts should build a comprehensive program, not just supply students and staff with machinery. Following is a listing of strategies that researchers have concluded contribute to the success of technology programs.

- **Planning.** Administrators may feel compelled to provide students with access to the latest technology and adopt initiatives without careful planning. It has been documented repeatedly, however, that detailed planning is a prerequisite for effective implementation of technology programs (Honey et al., 2005; Gahala, 2001; November et al., 1998; Cradler, 1996). Planners should align the program with the school system's primary goals and determine how the technology plan will relate to, support, and integrate with other educational plans at the district and state levels. Staff and student training required to integrate technology into the curriculum, as well as the technical support staffing needed to maintain the technology, should be specified (Alberta Education, 2006; Protheroe, 2005; Zucker, 2005; Cradler, 1996; Hopey & Knuth, 1996).

  Planners should conduct a thorough evaluation of program costs, including: hardware and software; related equipment (printers, scanners, and computer furniture); replacement of obsolete equipment; technical support; and other associated expenses (connectivity, wireless networking, security, insurance, and digital content). Experts recommend that anywhere from 20 to 33 percent of technology budgets be allocated for teachers' professional development. Outside sources of funding, such as grants and donations from local businesses, should be actively pursued (National Education Association, 2008; Alberta Education, 2006; National Center for Education Statistics, 2003; Whitehead et al., 2003; Freeman, 2002; Rodriguez & Knuth, 2000; November et al., 1998; Cradler, 1996).

- **Involving teachers in the planning and implementation of technology programs.** Experts agree that when teachers have input into planning and purchasing decisions, they are more likely to perceive the selected technology as useful and integrate the technology into their classrooms (National Education Association, 2008; Donovan et al., 2007; Lee, 2007; Marshall, 2004). The RAND Critical Technologies Institute (1995) examined schools that had been recognized by the U.S. Department of Education for their effective use of educational technology. The researchers found that teachers in these exemplary schools were involved in developing the program's learning goals and determining what part technology would play in meeting those goals. Teachers selected the equipment and technology-supported activities that would be used in their classrooms.

- **Providing all students and teachers with the appropriate tools.** Successful technology programs provide students and staff with access to updated software and well-functioning equipment (Alberta Education, 2006; Chaika, 2006; Zucker, 2005). Technology programs rarely have a positive impact on students when schools are limited to one computer for every 30 students or when available computers are out of date (Rivero, 2006; Cooley, 2001). The *Teachers Talk Tech 2005* survey found that over 61 percent of teachers nationwide believed there were too few computers in their classrooms (CDW-G, 2005). Experts suggest that one computer is needed for every two to five students (Cooley, 2001; Stratham & Torell, 1999).

  The National Education Association (2008) recommended that the technology available to students and teachers be compatible with the technology in general use outside of schools. Researchers have suggested that software be age appropriate, engaging, flexible enough to be applied to many settings, relevant to the content areas being studied, and able to be easily integrated into existing curricula (Waddoups, 2004; Culp et al., 2003).

- **Providing equitable access.** All students, regardless of the school they attend, must have equal access to technological resources (Alberta Education, 2006; Valdez, 2005; Cooley, 2001). Although inequalities still exist, some researchers have reported that gaps are gradually being narrowed (Fox, 2005; Warschauer et al., 2004). For example, nationwide in 1998, there were an average of 17.2 and 10.1 students per computer with Internet access in high- and low-minority schools, respectively (a difference of 7.1 students). Just three years later, there were 6.4 and 4.7 students per computer with Internet access in high- and low-minority schools, respectively (a difference of 1.7 students). A similar narrowing of differences has also been noted when comparing students in high- and low-poverty schools (Warschauer et al., 2004).

  Equity is not achieved, however, when some students use technology predominantly for drill-and-practice, while others use it for creative purposes. Honey, Culp, and Spielvogel (2005) found that students at high-poverty schools tended to use technology for more traditional remedial activities, while students attending low-poverty schools were more likely to use technology for communication and expression. Similarly, Becker (2000) reported that teaching in high-poverty schools correlated most strongly with using technology for “reinforcement of skills” and “remediation of skills,” while teaching in low-poverty schools correlated most strongly with “analyzing information” and “presenting information to an audience.” Warschauer, Knobel, and Stone (2004) concluded that, although student-computer ratios in high- and low-poverty schools were similar, students in high-poverty schools were more likely to be affected by uneven support networks and irregular home access to computers.

  Hohlfeld, Ritzhaupt, and Barron (2007) studied access to and use of educational software in Florida’s public schools, based on the proportion of economically disadvantaged students in each school (classified as high-SES and low-SES schools). Their sample included all elementary, middle, and senior high schools from Florida’s 67 districts that provided *System for Technology Accountability and Rigor* (STAR) survey data for 2003-04 through 2005-06. The study found that students at high-SES and low-SES schools had equitable access to software at middle and senior high schools. At the elementary level, students at high-SES schools had greater access to software than students at low-SES schools. No significant differences were found, however, in the way students used software in high-SES and low-SES schools at any school level. These findings led the researchers to conclude that the digital divide may not be as prevalent in Florida schools as it is in some other states.

  Yau (1999) suggested that educators adopt the following practices to support equitable access to technological resources:

- Provide the same equipment to schools, regardless of their ethnic composition and their students' socioeconomic status.
- Seek out instructional software that meets the needs and interests of limited English proficient, minority, and disabled students. Software should show both boys and girls from varying ethnic backgrounds in diverse roles and be available in more than one language.
- Allow all groups of students equal access to technological equipment before, during, and after school.

- **Integrating technology into the curriculum.** Experts agree that technology should not be treated as a separate subject or an occasional project, but as a tool to promote student learning on a daily basis. Educators must consider how technology will be used to support the curriculum and how integrating technology into instruction will support the district's broader instructional goals (Valdez, 2005; Starr, 2002; Cooley, 2001; Stratham & Torell, 1999; Hopey & Knuth, 1996). Chaika (2006) reported that successful technology programs selected applications that supplemented classroom instruction and used them to reinforce, enhance, and elaborate on existing instructional practices.

- **Providing Strong Leadership.** The importance of district and school commitment to the technology initiative is stressed repeatedly in the literature. Strong leadership by school boards, superintendents, district administrators, and principals is a key factor in developing school environments conducive to the effective use of technology. Leaders should advance a shared vision, provide a financial, long-term commitment to the program, and communicate regularly with schools and stakeholders about program implementation (Poole, 2008; Alberta Education, 2006; Zucker, 2005; Jackson, 2004; Educational Research Service, 2002; Johnston, 2000; Sivin-Kachala & Bialo, 2000).

- **Providing teachers with professional development.** Research clearly indicates that the single most important factor in the successful use of technology is teachers' ability to integrate technology into the curriculum (National Education Association, 2008; Chaika, 2006; The Greaves Group, 2006; Valdez, 2005; Jackson, 2004; Culp et al., 2003; Rodriguez & Knuth, 2000; Sivin-Kachala & Bialo, 2000; Kimble, 1999). Cooley (2001) stated that when school districts spend significant amounts of money on technology but don't prepare teachers to implement the program, the technology does little to enhance student learning.

  Some districts may not be providing teachers with the professional development experiences they need. According to the *Teachers Talk Tech 2005* survey (CDW-G, 2005), 28 percent of teachers nationwide reported they were not trained or inadequately trained to integrate computers into their lesson plans. Thirty-one percent of teachers indicated they received no training in computer or software use in 2004 or 2005 and 42 percent said they received only eight or less hours of training in the past 12 months.

  Before professional development is designed, each teacher's current level of technological skills should be determined (Bonifaz & Zucker, 2004; Gahala, 2001). A study conducted by Zhang (2005) found that a needs-based survey, administered prior to professional development sessions, helped schools design training that matched teachers' learning goals.

  Although research has not identified any one best model of effective professional development, approaches that have been found to be effective include:

  - Providing training in the skills needed to use the technology, in addition to strategies for its successful integration (Apple Computer, 2005; National Center for Education Statistics, 2003; McNabb, 1999). Teachers have consistently reported "lack of time to become acquainted with technology and how to use it" as one of the most significant barriers to its effective classroom use (National Center for Education Statistics, 2000).

  - Providing hands-on experiences using new skills and developing units in realistic settings with authentic learning tasks (O'Bannon & Judge, 2004; Rodriguez & Knuth, 2000).

- Modeling of appropriate integration strategies (Alberta Education, 2006).

- Instruction through case studies, allowing teachers to adapt and apply others' experiences to their own classrooms (Johnston, 2000).

- Linking professional development to the specific lessons currently being taught and to the skills students are in the process of mastering (CEO Forum on Education and Technology, 2001).

- Training on how to individualize technology applications to support different student learning styles (McNabb, 1999).

- Providing a variety of formats. Teachers have reported they value both formal training activities, such as workshops, and informal opportunities, such as team meetings, co-teaching opportunities, and demonstration lessons (Bonifaz & Zucker, 2004).

- Providing mentors, coaches, or peer teammates to give teachers opportunities for ongoing discussion and reflection with other teachers (Alberta Education, 2006; Apple Computer, 2005; Zucker, 2005; Rodriguez & Knuth, 2000). O'Bannon and Judge (2004) found that teachers who shared strategies for technology integration with colleagues used computers more effectively in the classroom.

● **Providing teachers with technical support.** Research has shown that the provision of adequate technical support is critical to the success of technology programs (Poole, 2008; International Society for Technology in Education, 2007; Hearrington & Strudler, 2006; Penuel, 2006; Apple Computer, 2005; Dexter et al., 2002 Educational Research Service, 2002; National Center for Education Statistics, 2000; Kimble, 1999). Technical specialists must be able to answer questions quickly, maintain or repair hardware, supply loaners, and install software (Grigano, 2004; Cooley, 2001; Gahala, 2001). Hearrington and Strudler (2006) recommended that technical specialists be responsible for supporting no more than 300 computers.

  Optimally, a full-time technical specialist, based at the school, is hired to provide technical support. When schools can't afford a full-time specialist, other options include (Poole, 2008; National Center for Education Statistics, 2003; Gahala, 2001; Rodriguez & Knuth, 2000):

- a part-time specialist or a district specialist who divides his or her time between several schools;
- students who are knowledgeable about computers and technology can provide technical support;
- parent and community volunteers who have advanced levels of technological knowledge can serve as advisors and trouble shooters when problems arise; and
- technical support can be outsourced to non-school personnel or companies.

● **Involving parents and community stakeholders.** Successful technology programs develop partnerships outside of the school system. Parents must be informed of technology programs to ensure their endorsement of innovations (Poole, 2008; Zucker, 2005; Jackson, 2004; Rodriguez & Knuth, 2000). Districts should collaborate with community organizations such as libraries and museums to provide support for initiatives (Alberta Education, 2006). In addition, partnerships and collaborations with businesses and local universities should be considered to help defray costs. For example, businesses can donate funds or supply volunteers to provide technical assistance and colleges or universities can offer professional development opportunities (Zucker, 2005; Gahala, 2001; Belanger, 2000; Rodriguez & Knuth, 2000).

● **Evaluating technology programs.** Experts recommend that school districts have a system in place for evaluating technology programs' impact on teaching and learning. Funding sources are usually more willing to support technology investments when there is research-based knowledge about the program's effect on instructional outcomes (Alberta Education, 2006; Culp et al., 2003). Districts often make the mistake of studying a variety of outcome measures that are not even associated with their program's goals (for example, when a district implements a program to increase equitable access to computers, but then evaluates the program's impact on students' reading and math test scores). Bonifaz and Zucker (2004) have suggested that districts measure only the variables related to their specific program objectives.

Research Limitations

More studies are needed before major investments in educational technology programs can be justified (Chaika, 2006; Apple Computer, 2005). Some of the reasons why researchers cannot state conclusively that technology programs lead to improved teaching and learning include:

- Few randomized, experimental studies have been conducted and variability in the types of hardware and software used has led to inconsistent findings. Furthermore, many studies don't supply the specifics needed to replicate their programs (Jackson et al., 2006). For example, Waxman, Lin, and Michko (2003) reported that 20 percent of the 42 studies they reviewed did not even describe the type of software used.

- The $2 billion per year classroom technology industry, reaping enormous financial benefits from the introduction of technology into schools, has commissioned numerous independent studies. These studies have concluded technology has a positive effect on education; however, they tended to be tightly controlled, short-term efforts that could not be replicated in real-life classroom settings, where students use whatever hardware and software are available, teachers implement programs to a varying extent, and students have a wide range of ability levels (Brodsky, 2007; Landry, 2002).

- Many schools combine the introduction of technology with other reforms, making it difficult to isolate the impact of the technology component. In addition, the introduction of technology into the classroom changes other variables, such as teachers' roles, levels of student collaboration, and students' study habits. It therefore becomes impossible to definitively state that the technology alone caused changes in student performance or behavior (Borja, 2006; Honey et al., 2005; Fouts, 2000; Roschelle et al., 2000).

- Essential components of technology programs (such as adequate professional development and high levels of technical support) are often missing from implementation efforts. Some research findings, therefore, are based only on partially implemented programs and don't reflect the results that might have been obtained had all aspects of the program been implemented (Fouts, 2000; Roschelle et al., 2000).

- Standardized tests may not be appropriate for measuring the changes in learning that occur when technology is used to develop specific skills or knowledge. Some researchers are calling for new standardized assessments that more accurately measure the skills technology helps students to develop, such as the ability to access, interpret, and synthesize information (Alberta Education, 2006; Honey et al., 2005; O'Dwyer et al., 2005; Protheroe, 2005; Valdez, 2005; Culp et al., 2003; Russell, 2002; Hawkes & Cambre, 2001; Fouts, 2000).

- Studies have tended to focus on just one year of implementation in a district or school, instead of several years, which would more accurately assess a program's impact on students and teachers. When long-term studies are conducted, the technology being evaluated is often out of date by the time the study is completed (Borja, 2006; Protheroe, 2005; Cooley, 2001).

Research on Educational Technology Integration

The question of whether the introduction of technology into the classroom has a positive impact on teaching and learning is still under intense debate within the educational community. Following is a summary of research conducted on educational technology programs. Studies are divided into the following categories:

most effective types and uses of technology; availability of technology; technology's effect on students' behavior; technology's effect on students' academic achievement; technology's effect on teachers; and professional development's effect on teaching and learning.

Most Effective Types and Uses of Technology

Several studies have examined the most effective types and uses of technology. In general, researchers have concluded that certain technology design features provide students with added benefits. More importantly, it appears that the types of activities students engage in determine if technology has an impact on instructional outcomes.

- Technology appears to be most effective when it is used to access information and when that information is used to communicate findings using graphs, illustrations, and animations. Researchers have suggested that technology serves different purposes, depending on the subject area. For example, to develop vocabulary, reading comprehension, writing, and spelling skills in language arts; to simulate and solve problems in math and science; and to simulate events and use multimedia to demonstrate work in social studies (Valdez, 2004; Sivin-Kachala & Bialo, 2000).

- Sivin-Kachala & Bialo (2000) summarized 311 reviews and reports on educational technology research. They concluded that the following software design features provide students with extra benefits:
    - packages that offer students some control over the amount and sequence of instruction, as opposed to those that control all instructional decisions;
    - programs with feedback identifying why a response is wrong, instead of identifying only what is wrong; and
    - software that includes embedded strategies, such as note-taking techniques, outlining, drawing analogies and inferences, and generating illustrative examples.

- There are trade-offs when deciding whether students should use technology collaboratively or individually. Students who work in groups at the computer have been found to interact more with their peers, use more appropriate learning strategies, and persevere more on instructional tasks. Students who work individually at the computer have been found to spend more time actually engaged with the software and complete their assignments more quickly, but require more help from the teacher (Sivin-Kachala & Bialo, 2000).

- Wenglinsky (1998) examined the National Assessment of Educational Progress (NAEP) math scores of fourth and eighth grade students from across the U.S. He controlled for factors believed to affect achievement, such as students' socioeconomic status, class size, and teacher education level and experience. Wenglinsky found that eighth grade students whose teachers used computers mostly for "simulations and applications" (generally associated with higher-order thinking) received higher NAEP scores than students whose teachers used computers primarily for "drill and practice" (generally associated with lower-order thinking). Fourth grade students whose teachers used computers mainly for "math/learning games" scored higher than students whose teachers did not use the games. No association was found between fourth graders' NAEP scores and teachers' use of "simulations and applications" versus "drill and practice." The data also indicated that students who spent more time on computers scored slightly lower on the NAEP. Wenglinsky concluded that the way technology was used was more important than how often students used computers. Wenglinsky subsequently replicated these findings with NAEP reading and science scores (Wenglinsky, 2005).

  In 2005, Wenglinsky examined the relationship between technology use and grade 12 students' NAEP history scores. Contrary to his earlier findings, no correlation was found between NAEP scores and the use of technology for history-specific tasks. Using technology for generic academic tasks, however, appeared to have a positive impact on NAEP scores. Wenglinsky concluded that the optimal role of technology for high school students was different from its optimal role with younger students. High school students benefitted from using generic technology-driven processes across subject areas, rather than the subject-specific applications needed at the elementary and middle school levels.

Wenglinsky's (2005) study on the effect of technology on grade 12 students' NAEP history scores found that many students did not have the technology skills needed to use computers in the classroom. For example, most twelfth grade students were proficient in word processing, but few had charting and graphing skills. Wenglinsky concluded that schools must provide training to students who lack basic computer skills before technology can be effectively integrated into the curriculum.

- Fuchs and Woessmann (2004) analyzed the Programme for International Student Assessment (PISA) reading and math scores of students from 32 different countries. They found that both the reading and math scores of students with Internet access were significantly higher than the scores of students without Internet access. In addition, reading and math scores increased as the frequency with which students used e-mail and web pages increased. Students who had educational software at home received significantly higher math, but not reading, scores. Fuchs and Woessman suggested that using computers at home for productive purposes led to increases in students' performance, but that the effect of home computer use on student achievement depended on the specific ways in which the computers were used.

- O'Dwyer, Russell, Bebell, and Tucker-Seeley (2005) studied the relationship between grade 4 students' use of technology and their performance on the English/Language Arts (E/LA) subtest of the Massachusetts Comprehensive Assessment System. The researchers analyzed data from students in 25 schools across nine districts and controlled for students' prior achievement and socioeconomic status. They found that students who reported higher frequencies of computer use for editing papers tended to receive higher E/LA scores, while students who reported higher frequencies of computer use for creating presentations tended to receive lower E/LA scores. The researchers suggested that students who spent more time creating presentations may have spent less time engaged in reading and writing. The frequency with which teachers reported using technology was not a significant predictor of students' E/LA scores. The researchers concluded that their study provided evidence that different uses of technology affected achievement in different ways.

Availability of Technology

Research focusing on the relationship between students' academic achievement and the availability of technology at school and in the home has produced inconsistent findings. Some studies have actually linked higher frequencies of school computer use to lower levels of academic performance and higher frequencies of home computer use to higher levels of academic performance. However, other factors, such as family background, school resources, and the type of activities students engage in with computers, appear to play a role in determining the impact of technology on student performance. Additional research is needed to clarify when and where technology provides students with the most benefits.

- To examine the relationship between students' academic achievement and their access to computers at school and at home, Ravitz, Mergendoller, and Rush (2002) analyzed the Iowa Test of Basic Skills (ITBS) reading, language arts, and math scores for 31,000 Idaho students in grades 8 and 11. They found that students who scored higher on the ITBS used computers more often at home and less often at school, even after they controlled for socioeconomic status. The researchers suggested that the lack of computer use at home may be a bigger barrier to achievement than lack of access at school.

  Ravitz and Mergendoller (2002) examined the relationship between students' self-reported software capability and their access to computers. They found that students with access to computers at both home and school rated their capability levels as higher than those with access to computers at only one location. Students with access to computers at home but not at school rated their software capability as average. Those with access to computers only at school rated their software capability as below average.

Students with no access to computers at either location rated their software capability as well below average. Ravitz, Mergendoller, and Rush (2002) found a positive relationship between students' levels of reported software capability and ITBS scores. Students who reported having higher levels of software capability not only received significantly higher scores than students reporting lower capability levels, but they also posted significantly larger score gains. However, the reader is cautioned that the methodology used in these studies does not permit cause and effect conclusions to be drawn.

- In 1998, Wenglinsky found that eighth grade students who reported frequently using computers at home received higher NAEP math scores than students who did not report frequent home computer use. In fourth grade, however, Wenglinsky found a negative relationship between frequent home computer use and NAEP math scores. He suggested that the two groups of students may have used computers in different ways, with eighth graders more likely to use them as tools for completing homework.

  In 2005, Wenglinsky found that the more time grade 12 students used computers for assignments outside of school, the higher they scored on the NAEP history test. The more time they used computers in school, the lower they were likely to score. Wenglinsky concluded that high-quality schoolwork using computers occurs outside of school and that teachers can use technology more effectively by requiring students to complete assignments at home.

- Bussière and Gluszynski (2004) examined the relationship between computer access and PISA reading scores. The researchers selected a random sample of students from more than 1,000 Canadian schools for their analyses. The found that infrequent use of computers at school was associated with higher PISA reading scores than no school use or heavy school use. However, a positive association was found between PISA reading scores and home computer use. Students with a computer at home scored, on average, half of a reading proficiency level higher than those without a computer at home.

- Fuchs and Woessmann (2004) analyzed the PISA reading and math scores of 15-year old students from 32 different countries. An initial positive correlation between computer use at home and students' PISA scores was explained by the fact that students from better economic, social, and educational family backgrounds tended to have more computers at home. Once family background characteristics were controlled for, the availability of a computer at home was negatively related to students' PISA reading and math scores.

  An initial positive correlation between computer availability at school and test scores reflected the fact that schools with more computers also featured other additional resources. After controlling for student, family, and school and classroom characteristics, the researchers found that school computer use and test scores had an inverted U-shaped relationship. In other words, students who reported intermediate computer use received higher PISA reading and math scores than those who reported no computer use or frequent computer use. Fuchs and Woessmann suggested that there may be an optimal level of computer use at school, with student learning initially increasing and then decreasing with the frequency of computer use.

- Jackson, von Eye, Biocca, Barbatsis, Zhao, and Fitzgerald (2006) studied the home Internet usage of predominantly Black and low-income children. Results of their analyses indicated that children who used the Internet at home more often received higher grade point averages (GPA) and higher scores on the Michigan Educational Assessment Program (MEAP) test of reading achievement. Internet use had no effect on MEAP mathematics scores. The researchers suggested that, since Web pages tend to be heavily text-based, children who spent more time online also spent more time reading.

- O'Dwyer, Russell, Bebell, and Tucker-Seeley (2005) studied the relationship between grade 4 students' use of technology and their performance on the English/Language Arts (E/LA) subtest of the Massachusetts Comprehensive Assessment System. The researchers analyzed data from students in 25 schools across nine districts and controlled for students' prior achievement and socioeconomic status. They found that students who reported higher levels of recreational home computer use received lower E/LA scores. No relationship was found between students' E/LA scores and their use of computers at home for academic activities.

- An evaluation of Microsoft's *Anytime Anywhere Learning* program at Walled Lake Consolidated Schools compared students with one-to-one laptop access to those who had access to computers through mobile laptop carts. The study found that both groups of students were engaged in similar types of computer activities, with all students most frequently using word processing software in language arts classes. Teachers of both groups of students were observed to act as facilitators, use computers as a learning tool, and engage students in sustained writing activities. The authors of the study attributed the similarities in classroom practices to the fact that one-to-one laptop students and cart students had both received substantial access to computers for instructional purposes and all teachers had participated in training on how to integrate technology into their classrooms (Ross et al., 2003).

- Mann, Shakeshaft, Becker, and Kottkamp (1999) examined the effects of West Virginia's *Basic Skills/Computer Education* (BS/CE) program on fifth grade students in 18 elementary schools. The researchers found that students who had access to computers in their classrooms scored significantly higher on the SAT-9 reading, language arts, and math subtests than students who accessed equipment in lab settings. Furthermore, classroom access to computers appeared to help the neediest children the most. Students who did not have a computer at home but had access to a computer in the classroom as part of the BS/CE program posted the largest test score gains in total basic skills, total language, language expression, total reading, reading comprehension, and vocabulary.

Technology's Effect on Student Behavior

Evaluations have concluded that the use of technology in the classroom has a positive impact on students' motivation, engagement, self-directed learning, and peer collaboration. Studies have also linked the introduction of technology to increased attendance rates and fewer disciplinary referrals. Other benefits reported have included higher levels of self-confidence, more positive attitudes toward learning, and the development of problem-solving, communication, and organizational skills. This research is outlined below.

- *Apple Classrooms of Tomorrow* (ACOT) was the first large-scale initiative to provide one-to-one computer access to students and teachers. The program operated in 13 schools from 1985 to 1998. Evaluations of ACOT concluded that participating students developed collaborative, problem-solving, and communication skills, became more independent learners, and had increased levels of self-confidence (Marshall, 2002; Cooley, 2001; Apple Computer, 1995).

- Stratham and Torell (1999) reviewed 200 studies on the effects of technology on student learning. They concluded that, when integrated appropriately, the introduction of technology into classrooms led to increased teacher-student interaction and encouraged cooperative learning, collaboration, problem-solving, and inquiry. In addition, students in "computer-rich" classrooms were found to have fewer absences and lower dropout rates.

- Waddoups (2004) analyzed 34 research studies that examined the impact of technology integration on student outcomes. He concluded that the use of technology in the classroom was tied to increased student motivation, more positive attitudes, and higher levels of self-esteem.

- The Northwest Regional Educational Laboratory's (2001) review of research on technology use with young children concluded that computers contributed to their cognitive and social development, increased motivation, and improved self-concept and attitudes toward learning.

- A study conducted on a one-to-one computing initiative at 150 middle schools in British Columbia concluded that the integration of laptops into the curriculum had a positive impact on students' attitudes, motivation, and work habits. Students were reported to be better organized, feel more responsible for their own learning, and have more confidence in their abilities (eSchool News, 2004).

- East Rock Elementary School in Connecticut provided all third and fourth grade students with their own laptops and fifth grade students with access to laptops in libraries. Teachers reported that students' motivation increased and that the computers encouraged student sharing, peer help, and peer communications. Students said computers made learning more interesting and fun and that they felt more responsible for their own learning (Delisio, 2005).

- An evaluation of programs that introduced interactive video applications into Ohio and South Dakota schools concluded that students had fewer absences following technology integration. Students were reported to be more engaged in their learning and to demonstrate higher levels of self-esteem and increased responsibility for their own learning (Hawkes & Cambre, 2001).

- An evaluation of the *Technology Immersion Pilot* (TIP) program in Texas high-need middle schools concluded that the program had a positive impact on students' attitudes and behavior. A comparison of students at 22 TIP schools and 22 control schools found that TIP students reported higher levels of school satisfaction and were more engaged in their classwork. TIP students had fewer disciplinary referrals and fewer suspension rates than control students. The program did not appear to have an impact, however, on students' attendance rates (Texas Center for Educational Research, 2006).

- Morgan and Ritter (2002) compared students taking algebra with a traditional curriculum versus those taking algebra with Cognitive Tutor (CT) software in five Oklahoma middle schools. They found that students in CT courses felt more confident about their math abilities and were more likely to rate math skills as useful.

- The *Maine Learning Technology Initiative* (MLTI) provided all seventh and eighth grade students and their teachers statewide with laptop computers. An evaluation of the program concluded that students believed laptops had facilitated their learning and improved the quality of their work. Teachers reported that students became more engaged in their learning and produced more and greater quality work (Silvernail & Gritter, 2007).

- The Mitchell Institute (2004) published findings from surveys of students and faculty at Maine's Piscataquis Community High School, following three academic years of *Maine Learning Technology Initiative* (MLTI) implementation. Survey results indicated that the laptop program was perceived to increase student motivation, peer collaboration, and interest in school and to improve interactions between students and staff. Teachers and students believed the program had improved the quality of student work and expanded opportunities for personalized learning. The daily student attendance rate improved from 91 percent to over 98 percent. The greatest improvements were seen for at-risk and low-achieving students.

- The *Tech-Know-Build Laptop Project* provided laptops and wireless Internet access to middle school students and teachers in two Indiana cities. A four-year study concluded that following the introduction of the initiative, students were more engaged in their schoolwork, developed better organizational skills, and had fewer absences and disciplinary referrals (Rockman, 2004).

- Multiple evaluations have been conducted of Microsoft Corporation's *Anytime Anywhere Learning Project*, a program that provided students and teachers at 800 schools with laptops for use at school and at home. Evaluations consistently reported that, following implementation of the initiative, students were more involved in their school work, collaborated more with their peers, directed their own learning, and relied more heavily on active learning strategies (Donovan et al., 2007; Gulek & Demirtas, 2005; Microsoft, 2000).

- Bebell (2005) conducted an evaluation of the *Technology Promoting Student Excellence* one-to-one computing initiative in six New Hampshire middle schools. Results indicated that teachers believed participation in the program increased student motivation and engagement and improved students' ability to work both in groups and independently. The program was believed to have the greatest impact on at-risk and low-achieving students, as evidenced by their increased classroom engagement and their improved ability to retain content material and work collaboratively with peers.

- In Virginia, Henrico County Public Schools implemented the *Teaching and Learning Initiative* that provided laptops to all middle and high school students, teachers, and administrators. An evaluation of the program found that teachers believed the use of laptops increased students' motivation and self-directed learning and students felt the use of laptops increased their organizational abilities (Zucker et al., 2005).

- *Classrooms for the Future* provided laptops and software to high school classrooms in Pennsylvania. The program began in 2006-07 and calls for implementation in all Pennsylvania public high schools by 2009. An evaluation of the program's first year found no increase in the percent of students engaged in their class work. However, among students already rated as engaged, their levels of engagement were reported to increase and they appeared to spend significantly less time off-task (Jobe & Peck, 2008).

Technology's Effect on Students' Academic Achievement

Studies have provided inconsistent results regarding the effect of educational technology on students' academic achievement. Although most research has concluded that the use of technology has a positive impact on students' writing skills, studies have reached varying conclusions regarding its impact on reading, language arts, math, and science performance. Research does seem to indicate, however, that the types of activities students engage in are more important than the frequency with which they use computers. Several studies have also suggested that technology programs have the greatest impact on low-achieving and at-risk students.

- In general, meta-analyses have concluded that the introduction of technology into the classroom has a small, positive effect on student outcomes when compared to traditional instruction (Valdez, 2005; Waxman et al., 2003; Murphy et al., 2001).

    - Goldberg, Russell, and Cook (2003) conducted a meta-analysis of 26 studies focusing on the impact of technology on the quantity and quality of student writing. They found that students who wrote with word processors tended to produce longer passages and higher quality passages than students who wrote with paper and pencil. The effect of writing with computers was larger for middle and high school students than for elementary students. Students' prior levels of academic achievement and keyboarding expertise did not play a significant role in either the quality or quantity of writing.

    - Kulik (2003) reviewed 27 studies to determine the effect of technology on students' reading, writing, math, and science performance. He reported that no firm conclusions could be drawn with regard to the impact of computer-based programs on students' reading, math, and science performance, although most studies found that computer enrichment programs had a positive impact on students' writing skills.

    - Haugland's (2000) review of the research indicated that three and four-year old children who engaged in computer activities that reinforced educational objectives showed greater developmental gains. Kindergarten and elementary-level children who used technology in the classroom demonstrated improved motor skills, enhanced mathematical thinking, increased creativity, and higher scores on tests of critical thinking and problem solving.

- The *Enhancing Missouri's Instructional Networked Teaching Strategies* (eMINTS) program began in 1997 in 13 Missouri elementary classrooms and has since expanded to include over 22,000 students in five states. Analysis of the Missouri Assessment Program (MAP) test scores of students in 32 schools found that a significantly higher percentage of third grade students enrolled in eMINTS classrooms scored at Level 4 (based on a five-category achievement level scale) on the communications arts test, compared to control group students. On average, students enrolled in eMINTS classrooms scored over 10 points higher than control students. At fourth grade, a significantly higher percentage of students enrolled in eMINTS classrooms scored at Levels 3-5 on the MAP math test, compared to control group students. On average, students enrolled in eMINTS classrooms scored approximately six points higher than control students. The program was also found to have a significant impact on free or reduced price lunch students' MAP scores (Huntley & Greever-Rice, 2007). These findings confirmed the results obtained in Bickford, Hammer, McGinty, McKinley, and Mitchell's (2000) analysis of grades 3-6 eMINTS students' MAP and TerraNova test scores. The Bickford study concluded that participation in eMINTS had a positive impact on student test scores at all grade levels.

- West Virginia's *Basic Skills/Computer Education* (BS/CE) program started in 1990-91 and ran for 10 years. The program provided students with regular access to computers and trained teachers in the use of hardware and software. Teachers were allowed to select software packages from one of two vendors that best fit their classroom needs and teaching philosophy. Mann, Shakeshaft, Becker, and Kottkamp (1999) analyzed the Stanford Achievement Test (SAT-9) reading, language arts, and math scores of fifth grade students in 18 elementary schools. Because the program was implemented statewide, no control group was available. The researchers found that students made significant test score gains in reading, language arts, and math. The type of software used had no effect on test scores.

- The *Maine Learning Technology Initiative* (MLTI) provided all seventh and eighth grade students and their teachers statewide with laptop computers. All teachers received professional development to help them integrate technology into instruction. Examination of eighth grade students' Maine Education Assessment (MEA) writing scores statewide indicated that average scores increased significantly after implementation of the program. Secondary analysis revealed that students who reported greater levels of laptop use in the writing process received significantly higher writing scores than those who reported not using their laptops for writing (Silvernail & Gritter, 2007). [It should be noted that Bowen (2007) has criticized the validity of these findings, claiming that the authors relied too heavily on subjective data and made selective use of MEA data. Bowen's critique is available online at http://www.mainpolicy.org/Portals/0/Issue Brief, No. 25.pdf.]

  The MLTI program started with nine pilot schools before expanding to all middle schools in the state. Muir, Knezek, and Christensen's (2004) evaluation of the nine pilot schools found that, following one year of program implementation, eighth grade MLTI students' science, math, and visual/performing arts MEA scores were significantly higher than control students' scores. Prior to program implementation, no differences had been noted between the two groups' scores.

- The Moore, Oklahoma Independent School District randomly assigned ninth grade students in five middle schools to either an Algebra I course using Cognitive Tutor (CT) software or a traditional Algebra I course. Students using the CT curriculum outscored students using the traditional curriculum on Educational Testing Service's (ETS) End-of-Course Algebra Assessment and received higher course grades (first semester grades only). Results were consistent across teachers and schools, as well as across students of both genders and all ethnicities (Morgan & Ritter, 2002).

- Evaluation of Microsoft's *Anytime Anywhere Learning* program implemented at Michigan's Walled Lake Consolidated Schools concluded that laptop students received higher scores on the district's writing assessment, compared to control group students, over a three-year period. Program students also scored significantly higher on five of seven components of a problem-solving task designed for the study. Analysis of Michigan Educational Assessment Program math, science, and social studies scores revealed no significant differences between treatment and control students, except on the geometry and measurement benchmark, following program implementation (Ross et al., 2003).

- Stevenson (1998) evaluated the long-term effects of the *Laptop Notebook Project* in the Beaufort County School District in South Carolina by analyzing seventh grade students' Metropolitan Achievement Test composite basic battery (reading, language, and math) scores. He found that program students maintained their percentile rank, while control students' percentile rank decreased significantly over this time period. Free or reduced price lunch students appeared to benefit the most from the project. By the end of the second year, they were scoring as well as control students who were not in the free or reduced price lunch program.

- Gulek and Demirtas (2005) examined the *Harvest Park Laptop Immersion Program*, implemented at a California middle school. The study analyzed students' grade point averages and California Achievement Test English/language arts, writing, and math scores. Program students were compared to a group of students who had similar levels of academic achievement prior to the commencement of the program. The study found that students who participated in the program earned higher grade point averages and test scores than control group students. It should be noted that teachers volunteered to participate in the program, so students were not randomly assigned to treatment and control conditions. Therefore, differences in student achievement following program implementation may have been caused by differences in the characteristics of teachers who volunteered to participate in the program.

- The U.S. Department of Education conducted a two-year study to determine if students received higher reading and math test scores when their teachers used software products designed to support instruction. One hundred thirty-two schools in 33 districts participated in the study. Districts and schools in the study had higher than average poverty levels and minority student populations and lower than average levels of student achievement. Teachers' use of software was not found to have an impact on students' reading or math scores at any of the grade levels tested (as measured by the Stanford Achievement Test and ETS' End-of-Course Algebra Assessment). The study identified several classroom characteristics that were related to student performance: at grade 1, students received higher reading scores when products were used in classes with lower student-teacher ratios; at grade 4, students received higher reading scores when products were used for longer periods of time. At all other grade levels, school and classroom characteristics were not related to student performance (Dynarski et al., 2007).

- Johnson (2000) studied the relationship between classroom computer instruction and the NAEP reading scores of a nationwide sample of fourth and eighth grade students. He found that computer instruction had no effect on reading scores. Students whose teachers used in-class computer instruction at least once a week did not receive significantly higher NAEP reading scores than students who received less instruction or no computer instruction at all. Johnson concluded that spending large amounts of money on technology programs reduced the resources available for other educational programs and materials.

- The *Technology Immersion Pilot* (TIP) program provided a wireless learning environment for students in economically disadvantaged Texas middle schools. The program included multiple components, including a laptop for every student and teacher, wireless access throughout the school, online curricular and assessment resources, professional development, and technical support. The Texas Center for Educational Research (2006) compared student academic achievement in 22 TIP schools and 22 control schools, matched on characteristics such as school size, regional location, and student achievement. Analysis of sixth grade students' Texas Assessment of Knowledge and Skills scores found that, after one academic year of program implementation, technology immersion had no significant effect on reading or math achievement. In fact, students in TIP schools scored slightly lower than students in control schools.

- The *Tomorrow 98* program provided 10 percent of Israel's elementary school students and 45 percent of its middle school students with new computers and software, as well as significant funding for teacher training. Fourth and eighth grade students were tested in Hebrew and math, using grade-normed achievement tests, at the conclusion of the school year. Data were collected from 122 schools. In Hebrew, no significant differences were found between program and control group students' scores at either grade level. In math, grade 4 program students' scores were significantly lower than the control group's scores. At grade 8, no significant difference was found between the two groups' math scores. The researchers concluded that the program may have displaced other educational activities that could have had a greater impact on students' levels of academic achievement (Angrist & Lavy, 2002).

- The *Tech-Know-Build Laptop Project* provided laptops and wireless Internet access to 3,000 middle school students and 175 teachers in two Indiana cities. Analyses conducted as part of a four-year study of the program revealed that the program had no significant impact on students' writing test scores or on their general levels of academic ability (Rockman et al., 2006; Rockman, 2004).

- The *Freedom to Learn* (FTL) program was implemented in 195 Michigan schools during the 2005-06 school year. The program was designed to increase achievement by integrating technology into K-12 classrooms. An evaluation of the program paired eight schools considered to be implementing the program effectively with eight control schools, matched on student and school characteristics such as socioeconomic status, ethnicity, reading and math achievement, and school size. Analysis of Michigan Educational Assessment Program writing, English, reading, and math scores indicated that the program did not have a strong impact on students' performance: in writing, FTL students significantly outperformed control students in only two of the eight school pairs; in math, FTL students significantly outperformed control students in only one of the eight pairs; no significant differences were found between FTL and control students' English or reading scores in any of the eight pairs (Lowther et al., 2007).

- In 2001, the Los Angeles Unified School District adopted the *Waterford Early Reading Program*, a technology-based reading instruction curriculum, for use in its kindergarten and grade 1 classes. A district evaluation examined data from 67 schools, matching treatment and control groups on student characteristics such as socioeconomic status and language classification. The Woodcock Reading Mastery Tests were administered to randomly selected students prior to and following program implementation. No statistically significant differences were found between program and control group students. However, kindergarten students used the program less than half of the recommended amount of time and first grade students used it less than one-third of the recommended time. The Los Angeles Unified School District has since dropped the program from its regular classes. Some district officials felt the program had not been implemented fully enough to have a significant impact; others believed the program was not successful because teachers had not been adequately trained to use the technology (Paley, 2007; Board of Education of the City of Los Angeles, 2004).

Technology's Effect on Teachers

Studies have concluded that teachers' attitudes and beliefs toward technology's role in the classroom, as well as their technological skill levels, influence the types of activities they use technology for and how often they integrate technology into the curriculum. Overall, the introduction of technology into the classroom has been found to have an effect on both teaching styles and the quality of student-teacher interactions. Frequently cited obstacles to technology integration include lack of preparation and practice time, equipment problems, and insufficient professional development.

- Studies have found that teachers use technology less often when they do not perceive it to be closely aligned with the curriculum. Teachers who were concerned students would use their laptops for unauthorized purposes also tended to use technology less often. Teachers who felt confident about their own technological abilities and their subject matter expertise were more likely to use technology in the classroom. Those who believed students were capable of completing complex assignments with technology or who viewed technology as a tool with a wide variety of applications were also more likely to integrate it into their lesson plans (Penuel, 2006; Apple Computer, 2005).

- Dunleavy, Dexter, and Heinecke's (2007) review of the literature concluded that the integration of technology into the classroom led to changes in teaching practices. Teachers reported designing more constructivist and student-centered lessons, using more inquiry-based activities, and acting more as facilitators than lecturers.

- The U.S. Department of Education's nationwide study concluded that teachers' use of reading and math software products led them to assume the role of facilitators in the classroom, with less lecturing and more assigning of independent student projects (Dynarski et al., 2007).

- Teachers participating in the *Apple Classrooms of Tomorrow* project reported that they enjoyed their work more and had more success with their students. They also reported that they interacted differently with their students, functioning more as guides and mentors and less as lecturers (Apple Computer, 1995).

- Evaluations of Microsoft Corporation's *Anytime Anywhere Learning Project* found that, following program implementation, teachers reported higher levels of confidence using technology in their lesson plans and felt a greater sense of control over their responsibilities for instruction and learning. Teachers indicated computers enabled them to use a more constructivist approach to teaching and rely less heavily on traditional teaching methods, such as lecturing and seatwork (Gulek & Demirtas, 2005; Microsoft, 2000; Rockman et al., 2006).

- The *Technology Immersion Pilot* (TIP) study conducted in Texas found that teachers at program schools collaborated more with other teachers and perceived themselves to be more technologically proficient than control teachers. TIP teachers used computers significantly more often than control teachers to integrate technology into their classrooms, for management purposes, and to support professional practices. It should be noted, however, that although TIP teachers used technology more often, they did not provide students with significantly more challenging lessons than control teachers. Students taught by both groups of teachers typically used laptops to perform the same types of activities they had previously completed with paper and pencil (Texas Center for Educational Research, 2006).

- Teachers in the *Maine Learning Technology Initiative* program reported that laptops helped them more effectively meet their curricular goals and individualize their curriculum to meet their students' needs. They also indicated that the program improved their interactions with students, especially those classified as at-risk or low-achieving. Teachers with more advanced technology skills and those who had attended four or more professional development activities were more likely to integrate technology into the curriculum (e-School News, 2004; Silvernail & Lane, 2004).

- Teachers In Henrico County Public Schools' *Teaching and Learning Initiative* program reported that the use of laptops provided them with more instructional flexibility and that their professional productivity and peer collaboration increased. They also reported having difficulty monitoring students' use of the laptops and finding time to learn and practice new instructional approaches (Zucker et al., 2005).

- An evaluation of Pennsylvania's *Classrooms for the Future* found that teachers spent significantly less time on whole-class lectures and significantly more time working with small groups or individual students. The content taught moved away from basic skills and toward higher-order thinking skills and assignments focused more on activities and hands-on projects. The biggest obstacles teachers reported were insufficient professional development, followed by computer failures and network downtime (Jobe & Peck, 2008).

- Lee (2007) found that California teachers who assigned computer activities most frequently were those who had established classroom management routines for ensuring that students had sufficient time to access the computers. Teachers who assigned computer activities most frequently and those who assigned tasks involving higher-order thinking skills believed allowing students to use technology provided unique learning opportunities. High-frequency teachers also spent more of their own preparation time on computers and reported a greater comfort level with technology. Teachers who assigned computer activities less frequently were more likely to believe other class work took priority over computer activities.

  Regardless of the frequency with which they assigned computer activities or the complexity of the activities they assigned, the majority of teachers cited limited time and problems with the equipment as barriers to program implementation. Teachers least likely to assign computer activities and those assigning low-level activities were more likely to report that the district used outdated software and took too long to respond to technical problems. However, the district supplied the same software and provided the same technical support to all teachers in the study. This finding led Lee to conclude that, although actual implementation barriers were similar for all teachers, the importance teachers placed on these barriers influenced the integration of technology into the curriculum.

- A survey to determine teachers' concerns when a one-to-one computing initiative was introduced in the southwestern U.S. found that the majority of teachers were concerned about how they would meet curricular goals once technology was introduced and the impact of the program on their planning time and instructional practices. Teachers were also concerned about their lack of information regarding the program's status. They worried about investing large amounts of time developing a new curriculum, only to learn the program was to be cancelled (Donovan et al., 2007).

Professional Development's Effect on Teaching and Learning

Research has indicated that the amount and type of professional development teachers receive is related both to student outcomes and to how prepared teachers feel they are to use technology in the classroom.

- Sivin-Kachala and Bialo (2000) reviewed 311 educational technology studies. They found that, among students in classrooms where technology had been introduced, students whose teachers had received more than 10 hours of training in the integration of technology into the curriculum scored significantly higher on standardized achievement tests than students whose teachers had received five or less hours of training.

- Wenglinsky (1998) reported that fourth and eighth grade students whose teachers received professional development in computers scored higher on the NAEP math test than students whose teachers had not participated in professional development experiences. In grade 4, students whose teachers had received professional development in technology scored .09 of a grade level (the equivalent of five weeks) ahead of students whose teachers had not received professional development. In grade 8, students whose teachers had received professional development showed gains of .42 of a grade level (the equivalent of 13 weeks) over students whose teachers had not received professional development. Teachers who received professional development in technology were more likely to use computers for teaching higher-order skills.

- Ravitz and Mergendoller (2002) found that Idaho students with higher technology-using teachers received higher ITBS scores and made greater test score gains, even after controlling for prior achievement levels. Based on a combined ITBS reading, language arts, and math score, the average high technology-using school scored at the 55th percentile, while the average lower technology-using school scored at the 46th percentile.

- Penuel (2006) found that teachers who engaged in 9 or more hours of professional development activities in technology were more likely to report feeling well- or very well-prepared to use computers and the Internet for instruction.

- In addition to the amount of professional development teachers receive, the content of training also appears to influence their use of technology. Kanaya, Light, and Culp (2005) reported that when teachers received training they perceived to be aligned with the curriculum and relevant to their teaching, they were more likely to integrate technology into their teaching. Ravitz (2000) found that teachers whose professional development emphasized multimedia applications and demonstrated integration techniques and strategies were more likely to integrate technology than those whose training encouraged mechanical skills or specific software applications.

On A Local Note

In December 2005, Miami-Dade County Public Schools' (M-DCPS) published the *Comprehensive Information Technology Blueprint*, a framework and five-year plan of action for using technology to provide students with the highest quality education. The document was developed under contract with CELT Corporation. Over 600 individuals, from principals to parents, assisted in its development. The blueprint is designed to provide equitable access, use, and support of technology resources for all M-DCPS students. Through implementation of the blueprint, students will be provided with the skills needed to compete in today's information-based global society. The complete *Comprehensive Information Technology Blueprint* is available online at http://itblueprint.dadeschools.net.

The Division of Instructional Technology has reported that the district continues to implement a computer refresh program to equip the district's schools with modern computers. According to Instructional Technology's description of the state of technology in the district, over 12,000 student desktop computers and 9,000 teacher desktop and laptop computers were installed throughout the district in just over a year. M-DCPS is now estimated to have a student-to-computer ratio of 3 to 1. The district also revised its technology standards for new classrooms, with specifications now including an interactive whiteboard and projector, an audio enhancement system, and four desktop computers.

In addition to classroom hardware, the district offers students a wide range of technology resources. Students have access to electronic materials, such as the Riverdeep suite of applications; Atomic Learning (for technological assistance); and reference tools (including Grolier Online, Facts on File, Gale Resources, NewsBank, eLibrary, and Social Issue Research Services). E-textbooks (electronic versions of district-adopted texts) are also available through the district's portal to offer students an interactive version of the text they use in the classroom.

Computer applications available at individual schools include:
- research-based applications which address issues such as reading readiness, algebraic thinking, geometric modeling, and English language acquisition;
- simulation software to develop planning and decision-making skills, as well as scientific thinking;
- concept mapping software to assist students in developing visual representations of objects and understanding the relationship between objects; and
- secondary school level courses that provide students with the opportunity to use and study technology in greater depth. Courses include computer programming, networking, and web design.

Throughout the district, individual programs have been implemented to provide students with greater access to technology. M-DCPS has also developed partnerships within the community and with local businesses to support the technology plan. Noteworthy individual technology programs include:

- Campbell Drive Middle School was awarded an *Enhancing Education Through Technology* (EETT) competitive grant to provide laptops to its seventh grade students. The program began at the end of the

2005-06 school year and extended through the 2006-07 school year. Because funding is no longer available through the EETT program for individual laptops, the school changed its deployment model and now provides laptops in carts in core content classrooms.

- The Young Women's Academy began providing students with laptops in January 2007. Currently in its second year of implementation, the program is used to support instruction in all content areas.

- The *Citibank Family Tech Program*, managed by the Education Fund, distributed over 8,000 refurbished desktop computers to students at selected elementary schools. The program began in 1998. Parents have received training on the use of computers given to their children.

- The *Dell TechKnow Program* is offered at approximately 30 schools for students in grades five through eight. Students participate in an after-school program that teaches them basic computer troubleshooting and repair. Upon completion of the program, students earn a refurbished Dell computer. Over 1,800 computers have been distributed through the program.

- M-DCPS entered into an educational compact with the City of Miami to implement the *Elevate Miami* project. The project provided approximately 600 computers to Title I sixth grade students in City of Miami schools. Teachers are implementing a series of lessons using technology to explore the community and develop life skills.

M-DCPS' Virtual School (M-DVS) was created in 2003 as an online high school content provider for students in Miami-Dade County. Courses are based on the Sunshine State Standards or the requirements of the College Board and are taught by state certified teachers. A variety of courses are offered, including electives, honors, and advanced placement. M-DVS provides online options for students who cannot accommodate required courses in their schedules; attend schools not offering specific advanced, honors, or special-interest courses; or need to retake failed courses. M-DVS began with two courses and has had as many as 41 offerings. There have been over 3,000 successful completions to date.

The Office of Performance Improvement, in collaboration with the Division of Instructional Technology (Miami-Dade County Public Schools, 2008), conducted a study to look at the feasibility of implementing a large scale laptop program in M-DCPS. The study concluded: "In sum, while there is a comprehensive technology plan in place, and while there are a number of laptop technology initiatives sprinkled throughout the District at this time, no formal studies have been conducted to ascertain the impact the District's technology investment is having on student learning or other desirable outcomes. . . It is the overall recommendation of this study to first investigate the impact of existing instructional technologies on teaching and learning in the District before launching into a subsequent generation of classroom technology at a time when the District is facing severe fiscal constraints."

The feasibility study conducted a cost analysis and determined that fully implementing a home-to-school or a classroom-assigned laptop program in M-DCPS would represent a significant investment of time and money. The cost analysis included expenses associated with hardware, connectivity, teacher training, and technical support. It was estimated that a one-to-one take-home laptop lease program would cost over $1,068 per student during the first year and over $1,002 per student in subsequent years (subsequent year expenditures are lower due to the elimination of one-time costs, such as network infrastructure, and a reduction in training costs). A one-to-one laptop cart program for core subject classrooms was estimated to cost almost $607 per student during the first year and almost $518 per student in subsequent years.

M-DCPS Staff Perceptions of Technology Programs

The *Florida Innovates Technology Survey*, formerly called the STAR (System for Technology Accountability and Rigor) Survey, is administered on an annual basis by the Florida Department of Education. The survey is designed to provide meaningful information about technology integration and capacity in Florida's schools. It is administered to all public schools in Florida and completed by the principal and technology specialist at each school. The survey response rate for 2006-07 was 97 percent.

Highlights of results for M-DCPS for the 2006-07 school year include (Florida Department of Education, 2007):

- Primary focus of the technology component of M-DCPS' School Improvement Plans:

	Elementary	Middle	Senior
Providing technology access & skills for all students	31%	28%	28%
Integrating technology into subject area instruction	10%	9%	16%
Procuring and maintaining hardware & software	3%	7%	4%
Using technology for select groups of students	3%	1%	2%
Using technology for administrative tasks	4%	5%	0%

- Percent of M-DCPS schools stating they don't have adequate funding to purchase or maintain hardware:

Elementary	Middle	Senior
43%	28%	31%

- Percent of M-DCPS schools stating they don't have adequate funding to purchase or update software:

Elementary	Middle	Senior
42%	30%	31%

- M-DCPS student access to computers:

	Elementary	Middle	Senior
Library/media center	7%	8%	7%
Classrooms	75%	48%	39%
General education labs	12%	20%	16%
Select school population labs	4%	14%	31%
Mobile computer labs	2%	11%	6%

- M-DCPS teacher access to computers:

	Elementary	Middle	Senior
Modern teacher desktops	77%	79%	65%
Non-modern teacher desktops	23%	21%	35%

- Technical support in M-DCPS:

	Elementary	Middle	Senior
Faculty member with other responsibilities	12%	8%	4%
Personnel dedicated part of day to tech support	17%	5%	8%
Personnel dedicated all day to tech support	52%	66%	60%
Personnel dedicated all day to tech support with help as needed	17%	22%	23%

- Average response time for technical support in M-DCPS:

	Elementary	Middle	Senior
Less than 4 hours	39%	45%	42%
4 to 8 hours	15%	27%	29%
9 to 24 hours	25%	22%	19%
Greater than 24 hours	21%	6%	10%

[Note: Based on information gathered annually by M-DCPS' Division of Instructional Technology, as of December, 2007, approximately 249 M-DCPS schools employed a full-time technician and approximately 75 schools shared a technician.]

Complete results from the 2007 *Florida Innovates Technology Survey* are available online at http://www.flinnovates.org.

Status of Technology in Florida Schools

Technology Counts, a joint project of Education Week and the Editorial Project in Education Research Center, grades states on their leadership in three core areas of technology policy and practice: access, use, and capacity (Education Week, 2008). States are surveyed on an annual basis to assess the status of K-12 educational technology across the nation. In 2008, the state of Florida earned an overall grade of B. The nation as a whole earned an overall grade of C+. Other highlights of the *Technology Counts 2008* report include:

- Florida earned an *Access to Technology* grade of B- (based on the percent of students with access to computers). The average for all states surveyed nationwide was a C.

- 97 percent of Florida's fourth grade students have access to a computer, compared to 95 percent of students nationwide.

- 81 percent of Florida's eighth grade students have access to a computer, compared to 83 percent of students nationwide.

- In Florida schools, there are 3.3 students per instructional computer, compared to 3.8 students per instructional computer nationwide.

- In Florida schools, there are 3.2 students per high-speed Internet-connected computer, compared to 3.7 students per high-speed Internet-connected computer nationwide.

- Florida earned a *Use of Technology* grade of A- (based on the creation of state standards for students in technology, the use of computer-based assessments, and the establishment of a virtual school). The average for all states surveyed nationwide was a B-.

- Florida earned a *Capacity to Use Technology* grade of B (based on the establishment of state standards for teachers and administrators in technology and the requirement of coursework or technology exams for initial licensure). The average for all states surveyed nationwide was a C.

In summary, M-DCPS' *Comprehensive Instructional Technology Blueprint* is designed to provide equitable access, use, and support of technology resources for all M-DCPS students. Individual technology initiatives are also being implemented at schools throughout the district. A feasibility study conducted by the Office of Performance Improvement, in collaboration with the Division of Instructional Technology, concluded that fully implementing a districtwide home-to-school or classroom-assigned laptop program would represent a significant investment of time and money at a time when the district is facing severe financial constraints. The report recommended that the district first investigate the impact of its existing technology before committing the resources needed to implement a large-scale program. M-DCPS staff responses to the *Florida Innovates Technology Survey* indicated that many schools feel they have inadequate funding to purchase hardware and software, but that most schools are receiving acceptable levels of technical support. At the state level, Florida earned an overall technology grade of B, while the nation as a whole earned an overall grade of C+. Florida also earned higher grades than those for states surveyed nationwide in all three core areas of technology policy and practice.

Summary

There is a growing consensus among educators and the general public that technology should play a more integral role in students' education. The introduction of technology into the classroom, however, doesn't automatically translate into better instructional outcomes. Researchers have found that many factors influence the level of a program's effectiveness, such as the extent to which teachers are trained and prepared to implement the program, the level of student access to technology, and the provision of adequate technical support. Researchers have identified strategies that contribute to the success of technology programs, including detailed planning, strong leadership, and parent and community involvement. Studies clearly indicate that the provision of professional development that enables teachers to integrate technology into the curriculum is the single most important factor in the effective use of technology.

The question of whether the introduction of technology into the classroom has a positive impact on teaching and learning is still under intense debate within the educational community. More studies are needed before major investments in educational technology programs can be justified. Findings from studies conducted on educational technology programs include:

- Certain technology design features provide students with added benefits, but many students first need training in basic computer skills before technology can be effectively integrated into the curriculum.

- Some studies have associated higher frequencies of school computer use with lower levels of academic performance and higher frequencies of home computer use with higher levels of academic performance. However, other factors, such as family background, school resources, and the types of activities students engage in with computers, appear to play a role in determining the impact of technology on student performance. Additional research is needed to clarify when and where technology provides students with the most benefits.

- Technology programs appear to have a positive impact on students' motivation, engagement, self-directed learning, and peer collaboration. Studies have also linked the introduction of technology to increased attendance rates and fewer disciplinary referrals.

- Most studies have concluded that the use of technology has a positive impact on students' writing skills, but findings have been inconsistent regarding technology's impact on reading, language arts, math, and science performance.

- The types of activities students engage in are more important than the frequency with which they use computers.

- Teachers' attitudes and beliefs about technology influence the types of activities they use technology for and how often they integrate technology into the curriculum.

- The introduction of technology into the classroom has been found to affect both teaching style and the quality of student-teacher interactions.

- Obstacles to effective technology integration most frequently cited by teachers include lack of preparation and practice time, equipment problems, and insufficient professional development.

- The amount and type of professional development teachers receive is related both to student outcomes and to how prepared teachers feel they are to use technology in the classroom.

M-DCPS' *Comprehensive Instructional Technology Blueprint* is the framework and plan of action for using technology to provide the district's students with the highest quality education. In addition, individual technology initiatives are being implemented at schools throughout the district. A feasibility study, conducted by the Office of Performance Improvement, in collaboration with the Division of Instructional Technology, concluded that the district should first investigate the impact of its existing technology before committing the significant resources needed to implement a large-scale laptop program. Results from this Literature Review support this conclusion. M-DCPS staff responses to the *Florida Innovates Technology Survey* indicated that many schools feel they have inadequate funding to purchase hardware and software, but that most schools are receiving acceptable levels of technical support. At the state level, Florida earned an overall grade of B on Education Week's *Technology Counts 2008* assessment of technology policy and practice. The nation as a whole earned an overall grade of C+. Florida also earned higher grades than those for states surveyed nationwide in all three core areas of technology policy and practice.

All reports distributed by Research Services can be accessed at http://drs.dadeschools.net under the "Current Publications" menu.

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