Evaluating the Effectiveness of Technology in Our Schools

ACT Policy Report

Richard J. Noeth
Boris B. Volkov

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Preface

The stated mission of the ACT Office of Policy Research is to inform policy makers and the general public on important issues in education by providing timely information that can directly enhance knowledge, dialogue, and decision making. The current ACT Policy Research Agenda focuses on six specific areas:

- Developing the Applicant Pool
- Increasing Diversity in College
- Remedial Education in College
- Retention in College
- Education and Workforce Transitions
- The High School Experience

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This study, *Evaluating the Effectiveness of Technology in Our Schools*, was initiated as part of the second author's summer internship at ACT (Boris Volkov is a doctoral student in the Educational Policy and Administration Program at the University of Minnesota). What began as a discussion of educational technology in our nation's schools has resulted in a resource to help policymakers and administrators evaluate the effectiveness of technological applications implemented to enhance teaching, learning, and achievement.

This policy report has greatly benefited from the contributions of many individuals. Several external-to-ACT educators provided considerable help in shaping the study and reviewing draft manuscripts. These individuals include James Bosco (Western Michigan University), Douglas Levin (American Institutes for Research), and William McInerney and Jennifer Richardson (Purdue University). The ACT Policy Research Advisory Panel provided recommendations about the formulation of the study and reviews of draft manuscripts.

Numerous ACT staff members were involved in various stages of the study. The following ACT staff provided help on the structure of the study and/or manuscript review: Patricia Farrant, Julie Noble, Wayne Patience, Nancy Petersen, Rose Rennekamp, Richard Sawyer, Cynthia Schmeiser, and Diane Schnelker. Braden Rood, Jacqueline Snider, and Andrew Welch provided assistance in manuscript preparation and bibliographic review. Gregory Carrier and Michael Rasmusson provided the graphic design, and Ken Kekke was the editorial manager for the report.

We are grateful for the assistance and support of the aforementioned individuals but accept sole responsibility for any errors of omission or commission.

Richard J. Noeth
Boris B. Volkov

Executive Summary

It is both reasonable and expected that technology should help lead the way to improve teaching and learning in our schools. Further, it is reasonable to believe that the ability to incorporate the educational opportunities that technology promises will help level the playing field throughout K–12 education—particularly across racial, gender, and geographic divides.

This policy report provides a view of the issues concerning the effectiveness of technology in its role to enhance education. This report is intended for use by educational leaders and policymakers who are concerned with making optimal use of technology in the schools. Specifically, this report:

- Focuses on issues that need to be considered as we assess the impact of technology and develop evidence-based strategies for technology integration that contribute to high achievement for all students.
- Provides useful information and specific recommendations about evaluating the effectiveness of technological applications implemented to enhance teaching, learning, and achievement.

Technology should be a tool to help educators meet the educational needs of all children. As such, technologies cannot function as solutions in isolation but must be thought of as key ingredients in making it possible for schools to address core educational challenges[1]. Technology can serve as an enabler in teaching and learning to:

- Help organize and provide structure for material to students.
- Help students, teachers, and parents interact, anytime and anywhere.
- Facilitate and assist in the authentication and prioritization of Internet material.
- Simulate, visualize, and interact with scientific structures, processes, and models.
- Help in learning history and depicting future trends.
- Serve as an extension and enhancer for handicapped populations.
- Provide automated translators for multilingual populations[2].

However, technology and equity are not inevitable partners. Simply providing access does not ensure that technology will effectively enhance teaching and learning and result in improved achievement. Nor does providing access imply that all teachers and students will make optimal use of the technology. Technology may mean little without appropriate objectives and goals for its use, structures for its application, trained and skillful deliverers, and clearly envisioned plans for evaluating its effectiveness.

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[1] Bennett, D., Culp, K. M., Honey, M., Tally, B., & Spielvogel, B. (2000). I*t all depends: Strategies for designing technologies for educational change*. Paper presented at the International Conference on Learning Technology, Philadelphia, PA.

[2] Bajcsy, R. (2002). Technology and learning. In *Visions 2020: Transforming education and training through advanced technologies*. Washington, DC: U.S. Department of Commerce.

Two yardsticks we can use to measure the strides technology has made are accessibility by students (and teachers) to technology resources and how technology is actually utilized by schools and teachers in different settings and for different students.

The rapid growth of school technology infrastructure has led to the increased availability and use of computers in schools. Most students now have access to computers and the Internet in their classrooms, nearly all students have access somewhere in their schools, and a majority of teachers report using computers or the Internet for instructional purposes[3]. While the number of students per instructional computer dropped, those in need are the most likely to lack Internet access. However, the ratio is improving rapidly in schools with the highest poverty concentration, as has the percentage of instructional rooms with Internet access[4].

But while they may have abundant computers, schools may not use them in the best ways to enhance learning. A great deal depends on the levels of planning, structure, preparation, and evaluation of the potential impact that technology will have on teaching, learning, and achievement. Experts believe that increasing capacity depends on enhancing the technology skills of teachers and administrators. Many states, for example, have taken steps to provide guidelines for how to use educational technology more effectively; and 80% have developed standards for teachers and administrators that include technology.

In terms of utilization, technology has expanded from use primarily as an instructional delivery medium to an integral part of the learning environment. Technology is serving at least four distinct purposes in the schools:

- To teach, drill, and practice using increasingly sophisticated digital content.
- To provide simulations and real world experiences to develop cognitive thinking and to extend learning.
- To provide access to a wealth of information and enhanced communications through the Internet and other related information technologies.
- As a productivity tool employing application software such as spreadsheets, databases, and word processors to manage information, solve problems, and produce sophisticated products[5].

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[3] Education Week. (2003, May 8). *Technology counts 2003: Pencils down—Technology's answer to testing*.

[4] Market Data Retrieval. (2002). *Technology in education 2002: A comprehensive report on the state of technology in the K–12 market*. Shelton, CT: Market Data Retrieval.

[5] Fouts, J. T. (2000). *Research on computers and education: Past, present, and future*. A report to the Bill and Melinda Gates Foundation. Seattle: Seattle Pacific University.

There seems to be universal agreement that a major criterion of technological implementation in the schools should be whether such applications actually do improve teaching and learning and increase student achievement. However, there also seems to be consensus about the complexity and challenge of reliably evaluating the effectiveness of technology.

It is a daunting task to separate the effects of technology from the effects of other factors that influence teaching and learning. Results and conclusions must be considered in the context of the interdependent set of variables in which the use of technology is embedded. These variables can include access, teacher preparation and experience, student background, curriculum content, instructional methods, and additional educational resources. Ascertaining technology's context as well as its impact calls for comprehensive evaluations that consist of both formative and summative components. Formative evaluations (during the course of the program) track the implementation of the technology. Summative evaluations (at the end of the program) examine the impact of the technology application.

Despite schools flooded with computers, the evidence is mixed as to whether overall student achievement has notably increased or the achievement gap has visibly narrowed as a result.

Research reviews have generally concurred that:

- When combined with traditional instruction, the use of computers can increase student learning in the traditional curriculum and basic skills area.
- The integration of computers with traditional instruction produces higher academic achievement in a variety of subject areas than does traditional instruction alone.
- Students learn more quickly and with greater retention when learning with the aid of computers.
- Students like learning with computers and their attitudes toward learning and school are positively affected by computer use.
- The use of computers appears most promising for low achieving and at-risk students.
- Effective and adequate teacher training is an integral element of successful learning programs based or assisted by technology[6].

[6] Ibid.

A great deal of the responsibility for successful integration of technology inevitably falls upon individual administrators and teachers. The most critical element in technology use is the preparedness and skill level of those who employ it. Teachers, for example, need high-quality professional development that leads to a professional community centered around the integration of technology into the curriculum. Viewed in terms of teaching, many recommend that teachers should have basic technology skills and be able to:

- Use technology for personal productivity.
- Use technology to support learning in a subject area.
- Design or adapt technology-supported learning activities.
- Manage student-centered, technology-supported activities.
- Assess student skills within the context of technology-supported activities[7].

Evaluation must pay careful attention to local program contexts. Evaluators must first examine the program's specific design describing how interventions are expected to bring about particular changes in teaching and learning. Evaluators must consider a range of factors such as scope of the evaluation, who the stakeholders and partners are, the kinds of data that are needed, and how the data will be used. There is often no consistent set of specific curriculum-related goals and objectives for the use of technology in teaching and learning.

Evaluation can consider human and technology inputs (student, teacher, school, classroom, and other contextual influences), process (types and areas of technology use in school and classroom), and expected and unexpected outcomes (student, teacher, family, school, and community achievements). Evaluation should not only be limited to outcomes and effects (summative), but should also be related to the process of implementing the program, its rationale,and the quality of its goals and objectives (formative).

Evaluation, then, can be formative and summative and include short-term, long-term, qualitative, quantitative, conventional, and innovative elements—or any combination. It can include a range of procedures—performance assessments, standardized tests, observations, writing samples, and other indicators of the impact of technology on achievement. Teachers can also participate in surveys and focus groups with students (and parents) about use of technology in the classroom.

Key stakeholders play an active role in supporting and modifying the evaluation process. The strategic approach to evaluating information systems in business, often called critical success factors, may be of use for evaluating K–12 technology use. This could involve district and school administrators, teachers, parents, and perhaps students convening to determine which factors are critical to the success of the technology implementation.

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[7] Means, B. (2000). Accountability in preparing teachers to use technology. In Council of Chief State School Officers, *2000 State Educational Technology Conference Papers*. Washington, DC: Council of Chief State School Officers.

The issues involved in evaluating the effectiveness of technology in education are complex. Yet technology, as a primary educational tool and major school expenditure, must be held accountable to its promise of enhancing teaching, learning, and achievement. Each day, educational leaders and policymakers at all levels are faced with questions and decisions about technology. Reliable information to help answer the questions and guide these decisions comes from comprehensive planning with key technology stakeholders and sound evaluation plans and practices. Following are a series of questions to address when considering technology evaluation:

- How and when will evaluation of technology's impact on teaching, learning, and achievement be done?
- Who will be responsible for collecting ongoing data to assess technology's effectiveness?
- How will accountability for implementation be assessed?
- How will the level of technological proficiency of students and teachers be assessed?
- How will technology be used to evaluate teaching and learning?
- What is the key indicator of success for each component of the technology plan?
- How will the effectiveness of disbursement decisions in light of priorities be analyzed?
- How will implementation decisions to accommodate for changes as a result of new information and technologies be analyzed[8]?

Given the critical need to effectively evaluate the teaching, learning, and achievement outcomes of technology, we offer three recommendations that can serve as reasonable benchmarks for those faced with the challenges of assessing the accountability of their school's and district's applications of technology:

1. ***All relevant stakeholders should reach consensus on the purpose and intended outcomes of the planned technology implementation.***
2. ***Every technology plan should include an evaluation component, and multiple evaluation methods should be considered, specified, and employed to assess agreed-upon outcomes.***
3. ***Administrators and teachers should receive adequate, tailored, and continuing education about how to best integrate technology into their schools and courses, and should be evaluated on their proficiency in doing so.***

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[8] North Central Regional Education Laboratory. (2003). *Evaluating the implementation of your technology plan*. Oak Brook, IL: North Central Regional Educational Laboratory.

1

Introduction

Technology is evolving at an astonishing rate. It has dramatically changed the ways we work, learn, interact, and spend our leisure time. Computers and information technologies have visibly revolutionized nearly every aspect of daily life—how and where we get our news, how we order goods and services, and how we communicate.

It is both reasonable and expected that technology should also help lead the way to improve teaching and learning in our schools. Further, it is reasonable to believe that the ability to incorporate the educational opportunities that technology promises will help level the playing field throughout K–12 education—particularly across racial, gender, and geographic divides.

Technology offers new ways of teaching and learning, and provides new ways for all involved in education to be openly accountable to parents, communities, and students (National Research Council, 1995). The National Academy of Sciences suggests that new and emerging technologies have the potential to enhance learning and the development of new knowledge in many exciting ways by providing access to a vast array of information and connections to other people—for information, feedback, and inspiration (National Research Council, 1999).

Despite such promise, however, there is varied evidence regarding the effectiveness of technology as it relates to educational equity and achievement issues (Barton, 2001; CEO Forum on Education & Technology, 2001; Cuban, 2001). One of the key goals of the No Child Left Behind Act is to enhance education through technology, with a specific focus on what works in technological applications (U.S. Department of Education, 2002a). Relatedly, the revised National Technology Plan (U.S. Department of Education, 2000) specifically calls for empirical studies to be conducted in schools and classrooms that are designed to determine which uses of technology are most effective—under which conditions and with which students.

This policy report provides a view of the issues concerning the effectiveness of technology in its role to enhance education. Partially in response to the technology focus of No Child Left Behind, this report examines much of the information available on the evaluation of technology in fostering educational equity and achievement. This report is intended for use by educational leaders and policymakers who are concerned with making optimal use of technology in the schools. Specifically, this report:

- Focuses on issues that need to be considered as we assess the impact of technology and develop evidence-based strategies for technology integration that contribute to high achievement for all students.
- Provides useful information and specific recommendations about evaluating the effectiveness of technological applications implemented to enhance teaching, learning, and achievement.

2

Technology in Our Schools

There is widespread belief that thoughtful and pervasive applications of technology[1] can help eliminate many educational inequities between inner city and suburban schools, between urban and rural districts, and those affecting minorities and people with physical and learning disabilities. Technology should be a tool to help educators meet the educational needs of all children. As such, technologies cannot function as solutions in isolation, but must be thought of as key ingredients in making it possible for schools to address core educational challenges (Bennett, Culp, Honey, Tally, & Spielvogel, 2000).

Bajcsy (2002) views technology in teaching and learning as an enabler and suggests that technology can work to:

- Help organize and provide structure for material to students.
- Help students, teachers, and parents interact, anytime and anywhere.
- Facilitate and assist in the authentication and prioritization of Internet material.
- Simulate, visualize, and interact with scientific structures, processes, and models.
- Help in learning history and depicting future trends.
- Serve as an extension and enhancer for handicapped populations.
- Provide automated translators for multilingual populations.

Similarly, Wilson (2002) envisions technology as offering endless possibilities to enhance educational experiences, expand academic opportunities, and develop critical employment skills. Others affirm the real promise of technology to be in its potential to facilitate fundamental, qualitative changes in the nature of teaching and learning (Thompson, Schmidt, & Stewart, 2000).

However, technology and equity are not inevitable partners (Johnson, 2002; Resnick, 2002; Whitehead, Jensen, & Boschee, 2003). Simply providing access does not ensure that technology will effectively enhance teaching and learning, and result in improved achievement. Nor does providing access imply that all teachers and students will make optimal use of the technology. Technology may mean little without appropriate objectives and goals for its use, structures for its application, trained and skillful deliverers, and clearly envisioned plans for evaluating its effectiveness.

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[1] The term "technology" often refers to a wide range of computer-based teaching and learning materials and applications, including all elements of computer use, Internet resources, various electronic communications, and distance education. Thus the terms *technology* and *computers* are used interchangeably in this report.

The Benton Foundation Communications Policy Program (2002) suggests that five factors must be in place for technologies to support real gains in educational outcomes:

- Leadership around technology use, anchored in solid educational objectives.
- Sustained and intensive professional development that takes place in the service of the core vision, not simply around technology.
- Adequate technology resources in the schools.
- Recognition that real change and lasting results take time.
- Evaluation that enables school leaders and teachers to determine whether they are realizing their goals and to help them adjust their practice to better meet those goals.

Similarly, two primary elements of the Technology Standards for School Administrators are leadership and vision (Technology Standards for School Administrators Collaborative, 2001). Under these standards, educational leaders are called upon to:

- Facilitate shared development by all stakeholders of a vision for technology use and widely communicate that vision.
- Maintain an inclusive and cohesive process to develop, implement, and monitor a dynamic, long-range, and systematic technology plan to achieve the vision.
- Advocate for research-based effective practices in the use of technology.

Accessibility and Utilization

Two yardsticks for measuring the strides technology has made are accessibility by students (and teachers) to technology resources and how technology is actually utilized by schools and teachers in different settings and for different students. Regarding accessibility, it is possible that more has been invested in the effort to incorporate computer technology into the K–12 system than in any other educational advance in history (Poole, 2001).

Computer Access. The rapid growth of school technology infrastructure has led to the increased availability and use of computers in schools. Most students now have access to computers and the Internet in their classrooms, nearly all students have access somewhere in their schools, and a majority of teachers report using computers or the Internet for instructional purposes (Education Week, 2003). According to the Department of Education (2002b), school Internet connectivity has grown from 35% in 1994 to 99% in 2001, while classroom connectivity—what counts most for instructional purposes—has increased from 3% in 1994 to 87% in 2001.

According to Market Data Retrieval (2002), the number of students per instructional computer dropped between 1984 and 2002 from 125 to 3.8 (or 5.6 per Internet-connected computer), suggesting that as more computers are added to classrooms, fewer students have to share them. At the same time, students in need are the most likely to lack Internet access. In 2001, high-poverty schools had 6.8 students per instructional computer with Internet access, compared to 4.9 students per computer in low-poverty schools. However, the ratio has improved rapidly (from 9.1 students in 2000) in schools with the highest poverty concentration. Similarly, the percentage of instructional rooms with Internet access in these schools increased between 2000 and 2001, from 60% to 79% in schools with the highest concentration of poverty and from 64% to 81% in schools with the highest minority enrollment (U. S. Department of Education, 2002b).

Extended access in schools has increased as well. For students without home Internet access, many schools provide such access outside of regular hours (e.g., before and after school). The U. S. Department of Education (2002b) reports that 51% of schools with Internet access made computers available to students outside of regular school hours. In addition, more than 20,000 technology services are spread across the nation and provide everything from specialized computer training to low-interest loans to help financially challenged families purchase personal computers for use at home (Education Week, 2001). These venues include public libraries, Department of Housing and Urban Development Neighborhood Network Sites, and Urban League centers.

New technology applications also are happening at an incredible pace. The Southern Regional Education Board (SREB, 2002a) reports that virtual learning is coming to K–12 schools faster than most realize. During the 2001–02 school year, SREB estimated that nationwide over 50,000 middle and high school students were enrolled in online courses.

Computer Use. But while they may have abundant computers, schools may not use them in the best ways to enhance learning. Dede (2002) reminds us that the important issue in effectiveness for learning is not the sophistication of the technologies, but the ways in which their capabilities aid and motivate users. The existence of a particular technology does not dictate the manner in which it will be used. Viewed in terms of teaching, Means (2000) recommends that teachers should have basic technology skills and be able to:

- Use technology for personal productivity.
- Use technology to support learning in a subject area.
- Design or adapt technology-supported learning activities.
- Manage student-centered, technology-supported activities.
- Assess student skills within the context of technology-supported activities.

A great deal depends on the levels of planning, structure, preparation, and evaluation of the potential impact that technology will have on teaching, learning, and achievement. Experts believe that increasing capacity depends on enhancing the technology skills of teachers and administrators—which is supported by the No Child Left Behind Act. Many states, for example, have taken steps to provide guidelines for how to use educational technology more effectively; and 80% have developed standards for teachers and administrators that include technology (Education Week, 2003).

In terms of utilization, Fouts (2000) reports that in the past decade technology has expanded from use primarily as an instructional delivery medium to an integral part of the learning environment. He indicates that technology is serving at least four distinct purposes in the schools:

- To teach, drill, and practice using increasingly sophisticated digital content.
- To provide simulations and real world experiences to develop cognitive thinking and to extend learning.
- To provide access to a wealth of information and enhanced communications through the Internet and other related information technologies.
- As a productivity tool employing application software such as spreadsheets, databases, and word processors, to manage information, to solve problems, and to produce sophisticated products.

How technology is actually utilized is a critical issue, and many schools may be using computers in ways that may not contribute significantly to their entire population's productive learning. Different groups of students within schools may use the computer in different ways. Female students have often steered (and been steered) away from science and technology options and have traditionally tended to use computers for more basic (e.g., word processing) rather than more complex (e.g., scientific modeling) purposes (Creighton, 2003; Education Week, 2001). Bolt and Crawford (2000) report a technology gender gap, much like in other aspects of society, where females tend to view computer technology with specific uses in mind rather than explore its myriad opportunities and applications.

Teachers of poor or minority children have often had a propensity to assign remedial drill computer programs rather than those demanding higher-order thinking and mastery of challenging concepts, including use of the computer for Internet research (National Alliance of Business, 2002). African American and Hispanic students have lagged behind in access to tasks involving simulations and applications that exercise higher-order thinking skills as opposed to drill and practice (Yau, 1999). Many teachers in high-poverty schools are less likely to have training both in technology-enhanced curriculum development and in using computers in their classrooms. They are also less likely to engage their students in solving complex problems using computers.

Teachers can have different expectations for how technology can be used for high and low achievers that may widen the achievement gap rather than narrow it. Education Week (2001) showed that teachers often believe that students with learning difficulties are less likely than their higher-achieving classmates to have rewarding experiences with technology. Moreover, devising methods for using challenging software with lower-achieving students takes considerable time, training, and practice. Schools with the highest poverty and minority concentrations were less likely to have special hardware and software for students with learning and physical disabilities than were schools with lower concentrations (U. S. Department of Education, 2002b).

Teachers of bilingual students may limit the use of technology in their classes as well. There is often little use by English-as-second-language students of computer labs and applications. In addition, there may not be a bilingual teacher or aide to assist in the lab (Education Week, 2001). Bilingual and English-as-a-second-language programs are also less likely to be given computers than mainstream programs or may receive obsolete machines with dated drill and practice software (Creighton, 2003).

Providing equal access to technology may not signify equal educational opportunity nor reduce the achievement gap for disadvantaged students. Children with disabilities, or who are minority, poor, or low achievers, may be left behind after the introduction of computers into schools. Even high-tech computers may often become not much more than trivial workbooks and control mechanisms for students in schools with predominantly minority enrollments (Education Week, 2001).

3

Evaluating Effectiveness of Technology as an Instructional Tool

There seems to be universal agreement that a major aspect of technological implementation in the schools should be whether such applications actually do improve teaching and learning and increase student achievement (Southern Regional Education Board, 2002b; U. S. Department of Education, 1998; U. S. Department of Education, 2002c). However, there also seems to be universal agreement about the complexities and challenges of reliably evaluating the effectiveness of technology (North Central Regional Education Laboratory, 1999; U. S Department of Education, 2002c; WestEd, 2002).

Technology is an integral part of our educational system, and it is a daunting task to separate the effects of technology from the effects of other factors that influence teaching and learning (Thompson, Schmidt, Walker, O'Connell, Bergland, Bengfort, & Linduska, 2000). Results and conclusions must be considered in the context of the interdependent set of variables in which the use of technology is embedded (Collis & Lai, 1996; Owen, Calnin, & Lambert, 2002; Russell, 2001).

These variables can include access, teacher preparation and experience, student background, curriculum content, instructional methods, and additional educational resources. Understanding technology's context as well as its impact calls for comprehensive evaluations that consist of both formative and summative components. Formative evaluations (during the course of the program) track the implementation of the technology. Summative evaluations (at the end of the program) examine the impact of the technology application.

Some of the Evidence

Despite schools flooded with computers, the evidence is mixed as to whether overall student achievement has notably increased or the achievement gap has visibly narrowed as a result of the use of technology (Barton, 2001; Cuban, 2001; Healy, 1998; Wenglinsky, 1998; Wilson, 1999; Yau, 1999). The following section presents selected reports that describe the differential and categorical effects of technological applications on teaching, learning, and achievement.

Summarizing the reviews of research on computers and education, Fouts (2000) indicates that, while not all reviews show outcomes in favor of computer use, the vast majority reach positive conclusions about their efficacy. He reports general concurrence that:

- When combined with traditional instruction, the use of computers can increase student learning in the traditional curriculum and basic skills areas.
- The integration of computers with traditional instruction produces higher academic achievement in a variety of subject areas than does traditional instruction alone.
- Students learn more quickly and with greater retention when learning with the aid of computers.
- Students like learning with computers and their attitudes toward learning and school are positively affected by computer use.
- The use of computers appears most promising for low achieving and at-risk students.
- Effective and adequate teacher training is an integral element of successful learning programs based on or assisted by technology.

He cautions that much of the research has been criticized for its low quality and suggests that these results are not guaranteed by the simple introduction of computers and related technology into the classrooms. Many other factors play important roles in the process.

WestEd (2002) examined selected research studies, ones they judged to be the most methodologically sound and that analyzed change over time. They concluded that a number of studies have provided convincing evidence that technology can be effective in teaching basic skills, and that computer-assisted instruction and drill and practice software can significantly improve scores on standardized achievement tests. They also state that technology can provide the means for students with special needs to communicate via e-mail and use the Internet for research, and also help teachers accommodate students' varying learning styles. They believe that there is substantial research that suggests technology can have a positive effect on student achievement under certain circumstances and when used for certain purposes. They list a number of key conditions that have repeatedly appeared in the literature as crucial elements for successfully using technology:

- Technology is best used as one component in a broad-based reform effort.
- Teachers must be adequately trained to use technology.
- Technological resources must be sufficient and accessible.
- Effective technology use requires long-term planning and support.
- Technology should be integrated into the curricular and instructional framework.

The Benton Foundation Communications Policy Program (2002) concludes that after more than two decades of research on the benefits of technology, evidence that demonstrates its positive effects on achievement is mounting. Specifically they conclude that:

- Large-scale statewide implementation of technology correlates with increased performance on standardized tests.
- Software that supports the acquisition of early literacy skills—including phonetic awareness, vocabulary development, reading comprehension, and spelling—can support student learning gains.
- Mathematics software, particularly programs that promote experimentation and problem solving, enables students to embrace key mathematical concepts that are otherwise difficult to grasp.
- Scientific simulations, microcomputer-based laboratories, and scientific visualization tools have all been shown to result in students' increased understanding of core science concepts.

They caution that, if technologies are used to support educational outcomes, there must be sustained professional development, technology leadership anchored in solid educational objectives, and evaluation that will help determine whether educational goals are realized and whether educational practices are appropriate.

In a report commissioned by the Software and Information Industry Association, Silvin-Kachala and Bialo (2000) summarized educational technology research from the late 1980s through 2000. They concluded that technology is making a significant positive impact on education. In addition to many of the preceding findings, they listed the following:

- A learning advantage has been found when students have developed multimedia presentations on social studies topics.
- Kindergartners who have used technology have benefited in areas such as improved conceptual knowledge, reading vocabulary, reading comprehension, and creativity.
- Educational technology has significant positive effects on student attitudes and achievement for special needs population—speech recognition being a valuable compensatory tool for the learning disabled.
- Use of online telecommunications for collaboration across classrooms in different geographic locations can improve academic skills.
- Technology has been found to have positive effects on student attitudes toward learning and on student self-concept.
- Students trained in collaborative learning on computers in small groups had higher achievement, higher self-esteem, and better attitudes toward learning, and these results were especially pronounced for low ability and female students.

They concluded that the specific student population, the software design, the educator's role, how the students are grouped, the preparedness of the educator, and the level of student access to the technology all influence the level of effectiveness of educational technology.

Finally, a study was recently requested by the Canadian Education Statistics Council to examine the impact of technology on that country's education. Among the results (Ungerleider & Burns, 2002) were that student attitudes toward computers and computer-related technologies improved as a consequence of exposure; the use of technology for group work was beneficial if teachers took into account the interplay among age of the students, kind of task, and amount of independence allowed; and the use of technology for mathematics instruction has a significantly positive effect on teaching high level concepts to students in grade eight and above.

Considerations for Evaluation

Dominant themes in the preceding reviews have implications for the design and implementation of technology evaluations. A great deal of the responsibility for successful integration of technology inevitably falls upon individual administrators and teachers. The most critical element in technology use is the preparedness and skill level of those who employ it (Wilson, 2002). Hart, Allensworth, Lauen, and Gladden (2002) suggest that once administrators provide students and teachers with sufficient and reliable technology, essential supports are needed to propel its use forward. Teachers, for example, need high-quality professional development that leads to a professional community centered around the integration of technology into the curriculum.

Education Week (2003) reports that some states have adopted technology requirements for initial licensure for teachers and/or administrators and several states require technology training or coursework for teacher or administrator recertification. Ten states currently offer professional or financial incentives for teachers to use educational technology, and 31 states provide such incentives for administrators.

Student achievement is often mediated by the processes teachers use to integrate technology into instruction. Technology can be used for drill and practice; it can be used to promote critical, analytic, and higher-order thinking skills, as well as real-world problem solving. Technology in schools may best be used in the ways adults use technology to accomplish their work—write, organize and analyze information, do research, and communicate (Rockman, 2000). The ability of teachers to foster such changes depends upon training that shows them how to integrate technology into content-specific instructional methods (Heinecke, Blasi, Milman, & Washington, 1999).

Cuban (2001) emphasizes a systematic approach to evaluating technological implementations that involves:

- Identification of educational needs.
- Specification of implementation goals.
- Design of instructional strategies to create effective learning environments.

While the conclusions about the efficacy of technology on achievement are mixed, some believe that the fault lies not with the technology-based innovations, but rather with evaluation plans and tools. Only a small number of school districts have established guidelines for evaluating the impact of educational technology (Whitehead et al., 2003).

Penuel and Means (1999) recommend that evaluation must pay careful attention to local program contexts. Evaluators must first examine the program's specific design describing how interventions are expected to bring about particular changes in teaching and learning. They advise that anticipated changes must be described in enough detail for stakeholders to know when desired changes have been achieved.
Second, evaluators must consider a range of factors such as scope of the evaluation, who the stakeholders and partners are, the kinds of data that are needed, and how the data will be used. There is often no consistent set of specific curriculum-related goals and objectives for the use of technology in teaching and learning.

The Iowa Consortium for Assessment of Learning with Technology (Thompson, Schmidt, Walker, O'Connell, Bergland, Bengfort, & Linduska, 2000) suggests that there are three fundamental elements that create the foundation for evaluation: school improvement, research, and technology. The Consortium explains that specific curriculum standards are selected as targets to inform teachers' work with technology, technology represents the cognitive tools that students use to impact and change the way they learn, and research will help design studies that contribute to the existing knowledge base.

Given the changing demographics of our society, it is important to know how students from different backgrounds acquire content meaning and come to new understandings through the use of computers. Social interactions in the classroom and the social aspects of school culture also affect the impact of educational technology (Zhao, Byers, Pugh, & Sheldon, 2001). School, community, and family culture are principal elements of the student's system of influences; this culture shapes the system and the subsequent outcomes of technology use (Peled, Peled, & Alexander, 1996). Evaluators should seek to understand the features of the technology implementation and its potential impact upon the social and ecological composition of the classroom.

Evaluation should grasp the effects of using technology at individual, organizational, and sometimes even community levels. This type of evaluation may be based on a system of learning benchmarks and other new means of assessments that take the context of evaluation into account (McNabb, Hawkes, & Rouk, 1999). The evaluation should depend on the educational needs, goals, setting, technology application, and expected outcomes (Milone, 1996; Russell, 2001). Rossi, Freeman, and Lipsey (1999) suggest that every evaluation be tailored to the particular purposes and circumstances of a given program so that it will be capable of yielding credible and useful answers to the specific questions at issue while still being sufficiently practical to actually implement with available resources.

As a rule, the closer the outcome measure is to actual student performance, the more confident evaluators can be about the impact of the educational program, including technological applications, on that performance (Kennedy, 1999). Depending on the educational needs and goals of the program, which are often tied to specific programs or funded projects, outcome measures might include changes in disciplinary referrals or completed homework assignments. In the long term, changes in test scores and other measures of performance, increased college attendance, increased job offers, measures of higher-order thinking skills, more sophisticated communication skills, research skills, and social skills might be included. Other measures might be perceptions about implementation benefits, attitudes toward learning, motivation, self-esteem, engagement levels, and retention (Fouts, 2000; Heinecke et al., 1999; Silvin-Kachala & Bialo, 2000; Ungerleider & Burns, 2002).

Ultimately, evaluation plans should reflect beliefs about how technology fits into the model of instruction, how it is utilized to improve teaching and learning, and, in so doing, how it increases student achievement, motivation, and value for learning (Russell, 2001). In addition, evaluation plans can include efforts to determine enhanced efficiency and cost-effectiveness, and examine whether technology is achieving better results at lower costs. Adequate evaluation can help improve existing technology programs so that they evolve to meet student and teacher needs, work to support multiple levels of learning, and foresee new developments.

Approaches to Evaluation. Evaluation can consider human and technology inputs (student, teacher, school, classroom, and other contextual influences), process (types and areas of technology use in school and classroom), and expected and unexpected outcomes (student, teacher, family, school, and community achievements). Evaluation should not be limited only to outcomes and effects (summative), but should also be related to the process of implementing the program, its rationale, and the quality of its goals and objectives (formative) (McNabb et al., 1999).

Evaluation, then, can be formative and summative and include short-term, long-term, qualitative, quantitative, conventional, and innovative elements—or any combination. It can include a range of procedures—performance assessments, standardized tests, observations, writing samples, and other indicators of the impact of technology on achievement. Teachers can also participate in surveys and focus groups with students (and parents) about technology use in the classroom.

Key stakeholders play an active role in supporting and modifying the evaluation process. The strategic approach to evaluating information systems in business—often called critical success factors (Rockart, 1999)—may be of use for evaluating K–12 technology use. This could involve district and school administrators, teachers, parents, and perhaps students convening to determine which factors are critical to the success of the technology implementation. They would then rank them according to their significance

and determine the role that technology should play in supporting the decision-makers in dealing with efficacy issues. This method provides a focus on issues that stakeholders regard as important and reflects a Baldrige quality approach to technology implementation (Walpole & Noeth, 2002). Bennett et al. (2000) provide a number of useful characteristics related to effectively evaluating technology. These include:

- ***Assumptions***
  - Technologies in and of themselves rarely bring about substantial change in teaching and learning.
  - The impact of technology on specific aspects of teaching and learning can be usefully understood only in context.
- ***Methodological features***
  - Evaluation is largely process oriented.
  - It is oriented toward change rather than doing better within the old framework.
  - Evaluation is multidisciplinary, combining elements from different fields.
- ***Design elements***
  - Long-term collaborations with teachers.
  - Systemic integration and research on the impact of innovations across multiple levels of the school system.

Building the evaluation capacity of districts and schools is critical, as is the willingness of staff to evaluate their efforts. Teachers, technology coordinators, school administrators, and evaluators can collaborate to identify the impacts associated with technology uses. Evaluation should build the capacity of teachers to assess technology resources and alignment of their uses with learning goals and content standards. McNabb et al. (1999) explain that some of the best results in evaluating technology come from schools that recognize and harness the expertise teachers have in identifying technology-induced learning outcomes. Having teachers train teachers to evaluate the effects of technology in the classroom presents a powerful professional development strategy.

Judgments about the effectiveness of technology should be made on the basis of specific, documented criteria. These criteria can be formulated at the outset of the implementation after gaining a thorough understanding of the nature of the implementation and the perceptions of its stakeholders. To diagnose strengths and weaknesses effectively, administrators and policy makers must know what outcomes are expected.

Educational programs and educational technology plans should have written objectives that provide understandable levels of detail. Where objectives are vague, evaluators should work closely with administrators to understand and clarify what the target audience should be able to know and do after technology implementation. Evaluation information will be especially useful when target goals and outcomes are agreed upon and documented by stakeholders and evaluators. Evaluators should also be attentive to the possibility of unplanned effects that might contribute to or hinder achievement.

4

Recommendations

The issues involved in evaluating the effectiveness of technology in education are complex. Yet technology as a primary educational tool and major school expenditure must be held accountable to its promise of enhancing teaching, learning, and achievement. While information is accruing, available evidence indicates that technology generally has demonstrated positive but limited results on improving the educational achievement of all students. Clearly, more information of a more rigorous nature is needed.

Each day, educational leaders and policymakers at all levels are faced with questions and decisions about technology. Reliable information to help answer the questions and guide these decisions comes from comprehensive planning with key technology stakeholders and sound evaluation plans and practices. To this end, the North Central Regional Educational Laboratory (2003) offers a series of questions to address when considering technology evaluation:

- How and when will evaluation of technology's impact on teaching, learning, and achievement be done?
- Who will be responsible for collecting ongoing data to assess technology's effectiveness?
- How will accountability for implementation be assessed?
- How will the level of technological proficiency of students and teachers be assessed?
- How will technology be used to evaluate teaching and learning?
- What is the key indicator of success for each component of the technology plan?
- How will the effectiveness of disbursement decisions in light of priorities be analyzed?
- How will implementation decisions to accommodate for changes as a result of new information and technologies be analyzed?

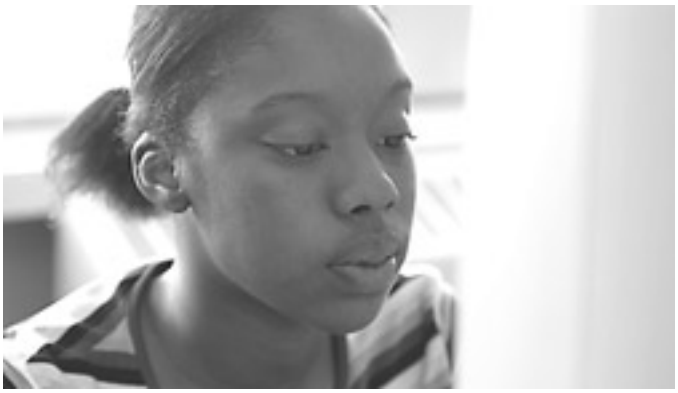
There are numerous resources to support the gathering of such information, from both the public and private sectors. A number of resources are listed in the bibliography of this report, and two federal resources that cover the necessary framework and details of technology evaluation in the schools are particularly worth noting:

- *An Educator's Guide to Evaluating the Use of Technology in Schools and Classrooms* (U.S. Department of Education, 1998)
- *Technology in Schools: Suggestions, Tools, and Guidelines for Assessing Technology in Elementary and Secondary Education* (U. S. Department of Education, 2002c).

Given the critical need to effectively evaluate the teaching, learning, and achievement outcomes of technology, we offer three recommendations that educational leaders and policymakers can include as part of all technology planning and evaluation. Though not exhaustive, they can serve as reasonable benchmarks for those faced with the challenges of assessing the accountability of their school's and district's applications of technology.

1. ***All relevant stakeholders should reach consensus on the purpose and intended outcomes of the planned technology implementation.***

The use and impact of technology in the school setting is far-reaching. There are many stakeholders who will influence or be influenced by technological implementations in the schools. Technology affects not only those most directly involved in teaching and learning (teachers and students), but also other stakeholders: administrators, other educators and school staff, parents, teachers and learners not directly involved in the implementation, community members, business leaders, school board members, and legislators. As districts and schools consider and reconsider technology implementations, they should include representatives of all groups who might potentially be affected, both in the short and long term, by the technology application(s).



The purpose and expected outcomes should be part of the discussions that conceptualize and create the technology implementation. The net that considers potential outcomes should be cast widely—to include not only the individuals and groups who might be impacted but also the content and context areas that might be affected (subject matter learning, social interaction, collaborative learning, tangential learning areas). All stakeholders should strive to reach consensus on the purpose and intended outcomes of the technology. This consensus should be documented as specifically as possible, including the qualification and quantification of all anticipated outcomes.

2. ***Every technology plan should include an evaluation component, and multiple evaluation methods should be considered, specified, and employed to assess agreed-upon outcomes.***

Schools and districts should have manageable technology plans that include a major focus on evaluation activities and outcomes—keeping the perspective that technological applications are one element within a complete instructional process. The discussion and design of the evaluation component should begin when technology programs are conceptualized and continue throughout (and beyond) program implementation. The evaluative element in technology programs should not be considered an add-on after the fact. Its components (e.g., goals, activities, measures, indicators, benchmarks, reporting methods) should be developed and agreed on by stakeholders. (Even if a program has begun without an evaluation component, it still may not be too late to institute an evaluation!)

Considerations should include the issues of formative evaluation (conducted during the implementation, allowing for mid-program refinements) and summative evaluation (end of implementation to determine effectiveness) in terms of importance to stakeholders, resources required, timing, and expected information received. Another consideration might be short-, medium-, and/or long-term evaluations—when they should be undertaken, how they would fit together, and what information might be gathered from each. The next level of consideration might include the types of evaluation (qualitative and quantitative) that might be conducted at each stage—surveys, standardized assessments, locally-developed measures, focus groups, teacher proficiency indexes.

3. ***Administrators and teachers should receive adequate, tailored, and continuing education about how to best integrate technology into their schools and courses and should be evaluated on their proficiency in doing so.***

Administrators and teachers are key technological interfaces in the schools: one is responsible for bringing technology into the district or building, the other for bringing it into the classroom. They are also major technology stakeholders. Successful technological implementations will largely depend upon the motivation, knowledge, and skill of administrators and teachers to implement and utilize technology in effective ways to enhance learning for all students. It is imperative that these educators be fully supported in this regard through adequate pre-service preparation, ongoing and state-of-the-art in-service activities, and links to local colleges and other resources for additional support and learning.

In return, administrators and teachers must be held accountable for the effectiveness of their uses of technology to support an enhanced learning environment for the educational community, as well as for subject matter learning for the range of students found in their classrooms. In other workplace environments, as new tools are incorporated into the work cycle workers are evaluated on their proficiency in utilizing them. Similarly, as educators are taught how to utilize technology to support teaching and learning, they should be held accountable for their ability to do so effectively.

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