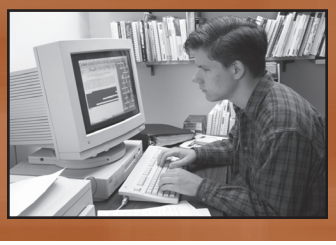
EDUCATION ISSUES



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A Primer for Policymakers

How Education Technology Leads to Improved Student Achievement

By Heather Grinager

November 2006

Introduction

There is little doubt that information and communication technologies have changed the world in which we live. They have enabled us to communicate, learn, work and relate to one another differently. This transformed world poses new and interesting questions for legislators who are searching for strategies to positively influence student achievement and who are seeking to ensure that the educational system adequately prepares students for the 21st century and tomorrow's challenges.

As the representative body that is responsible for the states' purse strings, legislators also are demanding more rigorous evidence that education funding is increasing student achievement before they make significant additional investments. In particular, because technology is a relatively new tool in education, a high level of scrutiny often is placed on technology's effectiveness. Nevertheless, in a time when high-stakes testing and restricted resources are driving forces in the delivery of public education, it is crucial for policymakers to have a realistic understanding of the existing evidence of technology's effect in education and the role it plays in teaching and learning. This brief reviews how technology is used as a tool to support teaching and learning, and how technology affects student achievement.

Why is education technology important? The use of technology in education provides students with technology literacy, information literacy, capacity for life-long learning and other skills necessary for the 21st century workplace. Books such as *The World Is Flat* by Thomas Friedman and recent reports such as *Rising Above The Gathering Storm: Energizing and*

What Is Education Technology?

Education technology typically refers to the use of hardware, software and other digital technologies to advance learning, teaching and administration in K-12 and postsecondary education settings. The following is a partial list of the types of technologies found in educational settings.

Computers — Laptops, desktops, handheld devices, etc.
Enterprise Management Software and Classroom Administration — Allows automation of processes and more efficient delivery of services; also enables data to drive school and classroom management, among other purposes (e.g. student information systems, transportation, facilities management, human resources, professional development, grade books, accounting and procurement).
Instructional Software and Digital/Online Content — Provides engaging, interactive, adaptive instruction/curriculum that enables anytime and anywhere personalization of learning to meet an individual student's needs and pace.
Student Information Systems and Data Warehouses — Enable the collection, analysis and management of student data to inform instruction, facilitate school/state decision making, and support accountability. Also introduce increased potential for individualized learning plans.
Interactive Whiteboards and LCD Projectors — Replace chalkboards in classrooms.
Sound Enhancement — Speakers and microphones in classrooms to amplify and enhance the quality of teachers' and students' voices.
Smart Cards — Replaces lunch tickets and lunch cards.
Global Positioning Systems — Track school buses.
Televisions — Distance learning and supplemental instruction.
Telephones — Communication with parents and community.
Digital Cameras, Camera Microscopes
Internet Access

Employing America for a Brighter Economic Future, authored by the National Academies, have raised concerns that America is falling from its once prominent position as the world's leader in technology and science. Technology helps prepare students for a world where they will compete with the best and brightest individuals from every corner of the globe. In addition, some argue that today's students, surrounded by digital technology since infancy, differ fundamentally from previous generations of learners the U.S. educational system was designed to teach.[1] Further embedding technology in education at all levels uses the tools students are accustomed to using outside the classroom, further engaging students in the learning process.

How does education technology lead to improved student achievement? A growing body of evidence demonstrates that technology is an effective means for addressing educational needs, goals and requirements. Educators also have identified links between technology and intermediate goals that lead to high achievement, including improved student behavior, engagement and attendance; improved opportunities for educator professional development; increased efficiency in classroom administrative tasks; and improved communication among stakeholders, including parents, teachers, students and administrators. As with all educational interventions, results do vary, depending upon the specific technologies used, the match of technology to educational needs and goals, the effective implementation of that technology, and how achievement is defined and measured.

Legislators considering investing in education technology must understand that an investment in hardware and software alone is not enough to lead to improved student achievement. Effective implementation is as important as the technology itself, and there are certain conditions that support effective implementation. The purpose of using technology should be to meet already established educational goals, and must be accompanied by a teacher who is properly trained to integrate it into teaching and instruction, as well as strong school leadership that ensures effective deployment and implementation. Adequate technical support and the appropriate school infrastructure, including adequate access to computers and bandwidth, are also important conditions that will help ensure technology has a positive effect on student learning and achievement.

Essential Elements to Ensure Technologies Are Used to Support Real Gains in Educational Outcomes

1. Leadership around technology use that is anchored in solid educational objectives. Simply placing technologies in schools does little good. Effective technology use is always targeted at specific educational objectives.
2. Sustained and intensive professional development that takes place in the service of the core vision, not simply around technology for its own sake.
3. Adequate technology resources in the school, including hardware and technical support to ensure smooth operation.
4. Recognition that real change and lasting results take time.
5. Evaluations that enable school leaders and teachers to determine whether they are realizing their goals, and how to adjust if necessary.

Source: Testimony and Statement of Margaret Honey, vice president and director, Center for Children and Technology, before the Labor, Health and Human Services, and Education Appropriations Subcommittee, U.S. Senate, July 25, 2001.

Digital Natives vs. Digital Immigrants

As technology continues to advance into every aspect of our lives, some have pondered the effects it has on how students learn. The phrase "Digital Natives and Digital Immigrants" has emerged to describe the difference between young people who have spent their lives in a digital world and past generations who have incrementally adjusted to the proliferation of technology in society.

The current generation of students who are proceeding through K-12 education are digital natives, and some argue that, by spending their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and other tools and devices of the digital age, they are fundamentally different from those who have adapted to use of these tools over time. Digital natives are accustomed to receiving information rapidly; can parallel process and multi-task; prefer viewing graphics before text; and function best when networked.[2] Some even argue that digital natives think differently. It is as though their cognitive structures are parallel, rather than sequential.[3]

This fundamental difference brings into question whether the current U.S. education system is designed to effectively teach digital natives. Educators may need to consider adjusting both teaching methodology and content to better engage digital natives in learning. Teachers will need to learn to communicate in the language and style of their students by going faster; using more parallel methods rather than going step-by-step. Although traditional content will remain central, it will be equally as important to present content that addresses technology issues, including understanding software, hardware, robotics, nanotechnology, and their ethics, politics, sociology and languages.[4]

Technology as a Tool for Learning and Teaching

When they are well implemented, instructional courseware, digital content and other electronic learning resources can help meet intermediary goals that can lead to improved student achievement, making technology an essential tool in teaching and learning in the 21st century. Quality electronic learning resources—in addition to being learner appropriate, aligned to state and local standards, and built around effective pedagogy and instructional design—can provide many educational benefits, including:

- Engaging students through multi-media, interactive content;
- Strengthening understanding and thinking skills through exploration, collaboration and creation;
- Adapting to support differentiated or personalized learning for students who have a specific learning style, pace or needs;
- Keeping knowledge current and information accurate;
- Enhancing accessibility for physical or learning disabled students through assistive technologies and presentation of content in alternative modalities; and
- Integrating testing and classroom management tools, thus allowing real-time tracking of student performance to inform instruction and provide accountability.

Education Technology and the Digital Divide

Education technology initiatives help bridge the digital divide. Embedding technology in education settings can help promote greater equity among students of different racial and socioeconomic backgrounds by increasing access to information and information technology for all groups. A report from the U.S. Department of Commerce found that minority and low-income students are much more likely to rely on their schools to provide access to computers and the Internet, and noted the "substantial equalizing effect of schools on both computer and Internet use as compared to use at home."[5]

Technology as a Tool for Learning

Numerous examples are available to illustrate how technology meets these goals. The late Dr. Jan Hawkins, former director of the Center for Children and Technology, suggests that technology is a powerful tool that gives teachers, students and others new ways to address problems such as shortages of materials, time and professional development. [6] For instance, technology brings rich and diverse materials into the classroom. Hundreds of libraries and museums have recorded parts of their collections in digital form and distribute these sources through the Internet and as software. Through a project called CoVis, students learn about science, using some of the same research tools and datasets used by scientists in the field. Using sophisticated software, the students collect and examine data on the weather, temperature, barometric pressure and atmospheric chemistry and are able to display and view the information in color-coded maps and graphs that help them understand and allow them to learn in a deeper way.

Technology also has the ability to change the dynamics of time and space in schools. By helping students work more independently, technology gives teachers more time to work one-on-one or with small groups of students. Assessment technologies also help teachers more efficiently identify students' strengths and weaknesses to better target instruction. With digital record keeping, phones in the classroom, and access to local networks to communicate with parents, administrators and colleagues, teachers can spend more time teaching and less on paperwork. In addition, students can extend their learning if they can connect from home to their school's network and to other courses and resources. [7]

Technology has allowed students and parents increased opportunities for individualizing, customizing and providing access to education through virtual or distance learning. Students who have struggled in traditional classrooms often find success in a virtual setting where the teacher and student communicate one-on-one through computer use and the student can proceed at his or her own pace. It also offers access to highly qualified teachers in hard-to-staff subjects or hard-to-staff urban and rural schools, giving all students the opportunity to take a rigorous curriculum, regardless of their school's ability to recruit and retain teachers. Thus, the traditional model of offering instruction only in dedicated, highly regulated facilities according to standard calendars and schedules is outdated, since "any time, any place, any path, any pace" learning that modern technologies make possible can open up the education system.[8]

When used effectively, technology applications can support higher-order thinking by engaging students in authentic, complex tasks within collaborative learning contexts.[9] These important "learning skills" enable people to acquire new knowledge and skills, connect new information to existing knowledge, analyze, develop habits of learning and work with others to use information.[10] Higher-order thinking and problem solving is an essential skill for all students as they face a future where they switch jobs far more frequently than past generations and will need to adapt and adjust to changing demands.

Education technology is increasingly important in light of the changed learning needs and styles of today's students. Today's students are growing up in a digital world and are masters of technology. They seamlessly integrate multiple technology tools and digital resources into their daily lives. Yet, too often, they are forced to leave these skills and aptitudes at the classroom door. As a result, students are increasingly disengaged in school and forced to adapt to a learning process and medium that contrasts significantly to that which is most comfortable

and successful for them. Therefore, technology that is carefully deployed in learning can engage and motivate students. For example, students say that, when they use the Internet, their motivation to learn and their academic performance improve. They complete their schoolwork more quickly, they are less likely to be stymied by material they do not understand, and their papers and projects are more likely to draw upon up-to-date sources and state-of-the-art knowledge. They also feel they are better at juggling their school assignments and extracurricular activities when aided by technology.[11]

Technology as a Tool for Teachers and Teaching

Technology can assist with aspects of professional development that ultimately can lead to better teaching. For example, follow-up assistance for teachers after they return to the classroom is an essential part of professional development that often is skipped because of the expense. Telecommunications technologies, however, allow coaches and mentors to be offsite but still answer questions, conduct seminars and offer support via e-mail or teleconferencing. Telecommunications also allow teachers who often may be isolated, to discuss the issues that arise when they are making changes to their practice.[12] A project in Iowa that has used technology to build professional learning communities also is finding that students in classrooms taught by teachers who are participating in the project are raising their test scores and showing signs of narrowing the achievement gap.[13]

Picture It: How Technology Supports Data-Driven Decision Making

Imagine an afternoon when a teacher can access a stationary computer or mobile digital device and quickly sort through reams of data stored and organized electronically to plan lessons for the next day. She'll review attendance records and test scores, ranging from the students' first years in school up to that very day. She'll see the courses her students have taken and every grade they've received. She'll compare each student's achievement against state standards to decide who needs review and who is ready to move on. All the information will be available by clicking a mouse and keying in a few words here and there. After her planning period, the teacher will have prepared lessons to match the needs of the students she'll see in class the next day.[14]

Now imagine that a parent, sitting at his or her home computer, can see the same information on the child as the teacher. Maybe the parent is able to see the lesson plan for the next day and use it to help prepare the child for what's ahead or when the child misses a day of school. The parent is able to see grades received on assignments, truancy reports and absences, and can use the information to help track the child's progress. Biannual parent-teacher conferences are supplemented with regular e-mail communication, using the up-to-date information on the student found in secure student information systems.

This scenario already is possible, but is too rarely found in classrooms today. The data systems infrastructure needed to support such applications do not exist in many places. According to Education Week, only five states—Arkansas, Georgia, Louisiana, Ohio and Tennessee—have advanced data systems for both students and teachers and the ability to link information from these two systems.[15]

Costs and Benefits of Implementing the Schools Interoperability Framework

Interoperability defined: The ability of software and hardware on multiple machines from multiple vendors to communicate.[16]

Student achievement has increased in schools and districts that have ensured seamless integration of information systems using the Schools Interoperability Framework (SIF). SIF defines the rules for data movement between applications, setting the standards for integration. Case studies found that districts that are using SIF standards in their implementation of data-driven decision making:

- Increased student achievement by raising test scores 30 percent through differentiating instruction, or "customizing" lessons and time with students to target their specific needs.
- Reduced data entry time, while allowing improved reporting capability, avoiding a single hire despite the increased state and federal NCLB reporting requirements.
- Qualified for increased funding due to enhanced reporting and better data about students who are eligible for free and reduced-cost lunch.
- Improved student services in the library because the librarian can focus on serving students rather than on performing data entry.

The costs of implementing SIF standards can very widely, depending on the nature of the solution and the kind of infrastructure, hardware and software the district already has in place.

Source: Schools Interoperability Framework, "Analysis of Costs and Benefits Associated with Implementing SIF" (Bellingham, Wash.: Educational Systemics Inc., June 5, 2006).

Technology is becoming a powerful tool in using data to make informed decisions. Although state accountability systems and the No Child Left Behind (NCLB) act have been the catalysts to encourage districts to establish student information systems and data warehouses-allowing them to track and analyze tests scores, grades, attendance, etc.-–the underlying goal of data-driven decision making is to increase student achievement. It does so by allowing teachers, administrators, parents and policymakers—each of whom has an important role in ensuring student learning—access to timely and comprehensive information that tells a story about a student's progress, problems and strengths.

Technology is an effective tool to improve productivity and efficiency. For example, in a 2004 survey of school leaders, 74 percent say technology provides timely data for decision making; 71 percent say it improves support staff efficiency; 71 percent say it increases administrators' productivity; 70 percent say it improves communications among parents, teachers and the community; and 61 percent say it increases teacher productivity.[17] Educator time is a scarce, costly and finite school resource. Technology helps maximize educational resources and impact.

Research on Technology's Effect on Student Achievement

Studies that isolate a particular technology to study its effect on some measure of student achievement find that well-implemented technology use can lead to improved student achievement. The following studies have been suggested by members of the NCSL Education Technology Partnership as studies that demonstrate increased student achievement as a result of using technology. Of course, as with all educational interventions and practices, a definitive relationship between computer use and student achievement is challenging to identify and

quantify since the link may depend on how the technology is used as well as on how achievement is defined and measured.[18]

Early studies sought to understand the effect of general computer use on student achievement. One large study conducted in 1994 found that, on average, students who used computer-based instruction scored at the 64th percentile on tests of achievement, compared to students in the control conditions without computers who scored at the 50th percentile. Although computers did not have a positive effect in every area in which they were studied, students who used them learned more in less time and reported enjoying their classes more.[19]

A similar study from 1998 found that both regular and special needs children in technology-rich environments experienced positive effects on achievement in all major subject areas in preschool through higher education. The research notes, however, that the level of effectiveness of educational technology is influenced by the specific student population, the software design, the educator's role, and the level of student access to the technology.[20]

A review of the research literature by the Software & Information Industry Association revealed positive and consistent patterns when students were engaged in technology-rich environments, including significant academic gains and achievement in all subject areas, increased achievement in preschool through high school for both regular and special needs students, improved attitudes toward learning, and increased self-esteem.[26]

States Show Improved Student Achievement with eMINTS

The Enhancing Missouri's Instructional Networked Teaching Strategies (eMINTS) program has been found to improve student achievement by improving the outcomes of students on test scores. Although it began in Missouri, the program has expanded to Illinois, Maine, Nevada and Utah. The program aims to inspire educators to use instructional strategies powered by technology, engage students in the excitement of learning, and enrich teaching to dramatically improve student performance. Extensive research and evaluation have demonstrated positive results on student achievement after implementation of this model.[21]

Test results show that, on most state tests, students enrolled in eMINTS classrooms score higher than students enrolled in non-eMINTS classrooms. In addition, low-income and special education students in eMINTS classes generally score higher than their non-eMINTS peers.[22] These results are encouraging, and it is important to recognize the various components of the program that contribute to its success. All eMINTS classrooms receive a variety of tools and support. Each teacher is part of a cluster and a cluster instructional specialist (CIS) is assigned to work with them. The CIS is available for consultation, support, facilitation and assistance in designing inquiry-based instructional experiences enhanced by technology. In addition, eMINTS classrooms have teacher workstations, interactive whiteboards, a computer for every two students, and related peripherals and software. Technical support is ample, as is the instructional support to ensure efficient operation of the classroom technologies and integration of the technologies into the curriculum.

Maine Is Learning How Laptop Program Supports Learning Goals

Maine has been a pioneer in providing laptops for all seventh and eighth grade students and teachers in the state. Research and evaluation of the program is ongoing, but initial findings from opinion surveys of students and teachers are positive. The results of teacher, student and principal surveys indicate that student use of the laptops for completing class work is higher for students who can take the laptops home. More than 70 percent of the teachers surveyed reported that the laptops helped them to more effectively meet their curriculum goals and individualize their curriculum to meet particular student needs. More than 75 percent of teachers reported that having the laptops helped them better meet Maine's statewide learning standards. More than 80 percent of teachers surveyed reported that students are more engaged in their learning, more actively involved in their own learning, and produce better quality work.[23]

More rigorous studies that evaluate the Maine laptop program's effect on student achievement are forthcoming.

The recent focus of the school improvement effort and NCLB has been on student achievement in reading and math. High-stakes testing and national and international comparisons often highlight these two content areas. There is now a gradual accumulation of evidence about the effect of technology on improving student performance in these areas.

Enhancing Sound in Classrooms to Benefit All Students

In 1977, the U.S. Department of Education began funding the initial investigation of what was to be a three-year investigation named the Mainstream Amplification Resource Room Study (MARRS Project). The results showed that all students, regardless of hearing ability, taught in sound enhanced rooms showed significant gains in academic achievement.[24] Most recently, *Technology and Learning Magazine* ranked providing sound field enhancements in classrooms one of the top return on investments schools can make with their technology funds.[25]

A review of the research literature by the Software & Information Industry Association revealed positive and consistent patterns when students were engaged in technology-rich environments, including significant academic gains and achievement in all subject areas, increased achievement in preschool through high school for both regular and special needs students, improved attitudes toward learning, and increased self-esteem.

A study that controlled for both prior achievement and socioeconomic status found that fourth-grade students who reported greater frequency of technology use at school to edit papers were likely to have higher total English/language arts test scores and higher writing scores on fourth grade test scores on the Massachusetts Comprehensive Assessment Systems English/Language Arts test.[27]

A study that compared student test scores on writing and essay tests found that those students who used a computer to take the test performed significantly better than those who took the test using paper and pencil. Nearly 70 percent of the students who took the computer-based test performed "adequately" compared to only 30 percent of students who took the test using paper and pencil. The authors suggest that, for students who have been accustomed to writing on a computer for only a year or two, estimates of student writing abilities based on responses written by hand may be substantial underestimates of their abilities to write when using a computer.[28]

A study in the Journal of Science Education and Technology examined the relationship between computer use and students' science achievement based on data from a standardized assessment. It found it is not the computer use itself that has a positive or negative effect on achievement, but the way in which computers are used.[29] For example, an Educational Testing Service study found that using computers to teach low-order thinking skills such as drill and practice had a negative effect on academic achievement, while using computers to solve simulations significantly increased students math scores.[30]

A 2002 study of Cognitive Tutor Algebra 1 on ninth grade students enrolled in algebra courses found that students who used the software tutor performed better than those who did not. This proved true for students across teachers, for male and female students, and for students of different ethnicity. Students who engaged with the software also were more likely to rate math as useful than students in a traditional class, and they were more likely to report that they were confident in math. Other studies of Cognitive Tutor have demonstrated that students participating in the program performed 85 percent better on average on assessments of complex math problem solving and thinking. In addition, students enrolled in Cognitive Tutor Algebra I have been shown to be 69 percent more likely to pass traditional geometry and 71 percent more likely to pass traditional algebra II.[31] The U.S. Department of Education, in a review of literature on middle school math interventions, included Cognitive Tutor, as well as another software program called I CAN LEARN, to be among the only interventions that the department reviewed with rigorous evidence of improving student achievement.[32]

When considering distance and virtual learning's effect on student achievement, it is important to recognize that this delivery method can transform education simply because it allows new and enhanced access to courses and curriculum that otherwise is often not available. In West Virginia, the Legislature required challenging courses for middle school students to prepare them for a rigorous high school program. Rural, isolated schools that had no access to a certified Spanish teacher and would not otherwise receive the course were offered Spanish I through a distance learning program. These students performed as well as those who had certified teachers in face-to-face instruction and, as the Spanish II teachers in high school report, they are equally accomplished and often are better prepared than those who had the traditional course.[33]

Research findings have shown no significant difference between online learning and face-to-face instruction—an indication that learning outcomes can be accomplished without a direct encounter with an instructor.[34] In fact, the International Journal of Educational Telecommunications found a small positive effect in favor of distance education and more positive effects for distance education programs that combine an individualized approach with traditional classroom instruction.[35]

Overall, research has established that properly implemented technology initiatives can improve student achievement, engage the digital native learner, and provide important technological skills to the future workforce. Most importantly, research reveals lessons learned about how to successfully use technology in education. As previously mentioned, this includes:

- 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.[36]

The above studies are a small sample of the research that examines technology's effect on student achievement. State policymakers are encouraged to contact NCSL with questions about implementation of a specific technology, policy strategies to ensure its effectiveness, and additional examples of successful schools and districts that have linked technology to improved student achievement.

Conclusion

Although research that seeks to understand technology's effect on student achievement will require ongoing effort, existing evidence is compelling that, with effective implementation, technology can lead to improved student outcomes. Policymakers may want to consider their own role in ensuring that education technology initiatives are sufficiently evaluated to draw lessons from emerging and developing strategies. Although the uniqueness of each school and classroom situation will always need to be considered, the accumulation of research evidence over time and across studies should provide consistent findings that enhance understanding of the role of teaching and learning with technology.[37]

Additional Resources

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