

Discussion Paper: Impact of Technology on Education

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December 2005

Background

The current trend to globalization and the growing influence of technology on our lives mean that today's students need to acquire different and evolving skill sets to cope and thrive in this changing society. As computers are growing in importance in every aspect of society, many consider that it is better to expose children early to this evolving technology.

Our education institutions must prepare students to work in a computer-filled economy. Over 50% of American workers use a computer at work and this is growing rapidly. Rules-based tasks are increasingly being computerized and/or outsourced; therefore work for a growing number of Americans will be tasks that cannot be processed simply by following rules. We will need to teach our students to identify and solve problems (expert thinking); and to engage in complex human interactions (leading, teaching, marketing & negotiating). If the U.S. is to maintain its high technology status in today's global economy, computers must be given a more integral role in our schools. We will need to focus on fostering 21st century skills and knowledge rather than preparing students to do well on high stakes standardized tests.

Students are more than ready to embrace technology in education. Today's students have grown up using digital technology. Surveys show that, of young people aged 12-17:

- Over 50% have their own blog or contribute to another blog or website
- Over 50% download music
- 90% use the internet to search for information for class assignments
- 80% are given internet assignments to complete at school
- 60% are using online dictionaries, encyclopedias and thesauruses
- Over 70% say that having access to the internet helps them earn better grades & be stronger students

Technology adoption in U.S. schools

Despite the prevalence of technology in many parts of society, schools lag far behind in the use of technology. This is the case, despite massive investments in educational technology. Since 1996, state and district level agencies have invested over \$10 billion to acquire and integrate computer-based technologies into American schools. The federal government has spent an additional \$3 billion. This has been one of the most costly educational initiatives in recent times. The U.S. ratio of students to computers has dropped from 125:1 in 1983 to 4:1 in 2002. From 1984 to 1997, the number of computers in U.S. schools increased eleven-fold to over 8 million units. At present, approximately 98% of U.S. schools have Internet access.

The use of laptops in schools is increasing as well. An estimated 12% of U.S. schools have used laptops as an instructional tool. There is a growing trend to employ 1:1 laptop programs to provide students with 24/7 access. This is made possible, partly due to the decreasing weight of laptop computers and the increasing availability of wireless access. A leader in laptop use, the State of Maine

has provided Apple iBooks to all middle school students and teachers and 25% of high school students and teachers. Henrico County in Virginia and Cobb County in Georgia have provided laptops to all middle and high school students. Texas is currently implementing a statewide rollout by providing laptops to all high school students. Goals of laptop programs often include some or all of the following:

- Improved academic achievement
- Increased equity of access/overcoming digital divide
- Increased economic competitiveness of state or region
- Effecting a transformation in quality of instruction through increased student-centered instruction; differentiated learning; problem or project-based learning & use of higher order thinking skills.

Current and future applications of technology in education

Students and teachers are using a variety of technologies across subject areas including:

- Developing online blogs and podcasts to refine reading, writing & research skills
- Using Voice over IP to talk to other students around the world for free
- Online education to reach rural & remote students
- Teachers using video clips from IPTV to streaming video to enhance lessons
- Interactive whiteboards to replace chalkboards, handouts and possibly, even textbooks
- E-books are replacing textbooks in some schools
- Handheld technologies: podcasting, digital video, & GPS
- Texas using iPods for vocabulary development through preloaded songs and course lessons for English language learners and kindergarten students
- Use of classroom blogs to enhance communications with students & parents
- Using software and online resources to learn foreign languages
- Use of online dictionaries, encyclopedias & thesauruses
- Use of word processing and hypermedia authoring software in writing process
- Spreadsheet creation
- Collecting data from CD-Rom encyclopedias, internet, science probes & GPS
- Using laptops to write, take notes, complete homework, keep organized, communicate with peers & teachers and research topics on internet

In 2004, the federal Department of Commerce encouraged students to participate in developing “Visions 2020” by providing input on potential technologies and how they might be applied in education. Over 160,000 students participated, 38% from K-5 and 62% were 6-12th grade. Student responses were broad and far-reaching and have been encapsulated in the following quote:

“Every student would use a small, handheld wireless computer that is voice activated. The computer would offer high-speed access to a kid-friendly Internet, populated with websites that are safe, designed specifically for use by students, with no pop-up ads. Using this device, students would complete most of their in-school work and homework, as well as take online classes both at school and at home. Students would use the small computer to

play mathematics-learning games and read interactive e-textbooks. In completing their schoolwork, students would work closely and routinely with an intelligent digital tutor, and tap a knowledge utility to obtain factual answers to questions they pose. In their history studies, students could participate in 3-D virtual reality-based historic reenactments.”

This suggests a multitude of directions to go with educational technologies in the future that will require changes in many aspects of schooling including instructional strategies, scheduling and more.

Studying the impact of technology on student achievement & instructional practices

As is the case with many educational reforms, it is difficult to isolate the impact of technology on student achievement. Much of the literature relies on survey data rather than pure empirical research. In addition, many researchers suggest that the traditional measure of student achievement, namely standardized test scores may not adequately assess the impacts of technology. The reason for this is that test scores do not necessarily measure the development of the higher order creative and critical thinking skills that are identified as a valuable outcome of the use of educational technologies. Despite these difficulties, it is critical to evaluate whether the tremendous investment in computer technologies in schools is providing an adequate return in terms of student achievement to guide ongoing multi-billion dollar policy decisions.

Prior educational research has shown that students who engage in collaborative work and participate in more project-based learning have higher levels of motivation leading to higher levels of achievement; and that learning increases significantly when students are engaged in academic study through authentic, real-world experiences. Much of the research on the impact of technology considers the degree to which the use of computers results in an increase in these practices and the resultant impact on student achievement.

The following are highlights of a number of studies, which examined the impact of educational technology:

- A 1994 meta-analysis of over 500 studies regarding the impact of computer-based instruction (CBI), defined primarily as tutorial, drill and practice software found that students learned more in less time; liked classes more; and developed more positive attitudes when classes used CBI.
- In the early 90's, the “Apple Classrooms of Tomorrow” (ACOT) project encouraged instruction innovation and emphasized to teachers the potential of computers to support student initiative, long-term projects, access to multimedia resources and cooperative learning. A 1994 analysis of the impact of ACOT identified a positive impact on student attitudes and a change in teaching practice to more cooperative group work and less teacher stand-up learning, but did not find any positive impacts on student performance on standardized tests.
- As a part of the “Computer Supported Intentional Learning Environment” (CSILE) project, children were to ask questions, search for other students’ answers to their questions, comment on and review other students’ work, and then restructure and formulate answers to their original questions. A 1996 study found that CSILE students surpassed other students on

measures of depth of understanding, reflection and on standardized tests in reading, language arts & vocabulary.

- A 1998 review of 219 studies on the effects of technology on learning, consistently found that students in technology rich environments experienced positive effects on achievement in all subject areas and that this was the case for both regular and special needs students. The author also concluded that attitudes towards learning and self-concepts improved when computers were used for instruction.
- A study, published in 1998, analyzed the impact of computer use on 1996 4th & 8th grade math scores on the National Assessment of Educational Progress (NAEP). The researcher concluded that both 4th & 8th grade students who used simulation and higher order thinking software had significantly higher math achievement. However, he also concluded that students who used drill and practice technologies performed worse on NAEP math tests than did students not using these techniques.
- Analyses of West Virginia's Basic Skills/Computer Education (BS/CE) program found positive impacts on student achievement among 5th graders who had been involved in this initiative as measured by significant gains in Stanford 9 reading, writing and math scores. The greatest gains were associated with lower achieving students. A cost/benefit analysis of BS/CE in 1999 found it to be more cost effective, in raising student achievement, than other popular interventions including reducing class size from 35 to 20; increasing instructional time; or cross-age tutoring programs.
- Microsoft's "Anytime Anywhere Learning Project" provided laptops to 125,000 students in 800 schools beginning in 1996. An evaluation of the project, conducted in 2000, found that teachers and students report that students involved in the project were more likely to:
 - engage in collaborative work
 - participate in project-based instruction
 - produce more writing & higher quality writing
 - have greater access to information & improve research analysis skills
 - direct their own learning
 - readily engage in problem-solving & critical thinking skills
 - spend more time doing homework on computers.
- A 2000 study sponsored by the Heritage Foundation compared student achievement with the frequency of in-class computer use by trained teachers as well as a number of other factors such as race, parents educational levels, income, gender, etc. The study results demonstrated that the frequency of computer use in school did not have a statistically significant impact on academic achievement in 4th or 8th grade based on NAEP data.
- A 2003 meta-analysis of 99 recent studies considered the effect of the use of word processing on student writing in terms of both quantity and quality, using a wide range of measures of writing dimensions. Results of the data analysis showed that use of a word processor for writing had a positive impact on the quantity of student writing, more so for middle and high school students than for elementary school students. A positive effect on the quality of writing

was also identified but the effect was smaller. Further analysis of the non-quantitative studies suggested that the use of word processing in the writing process leads to increased collaborative writing and peer editing; higher motivation to write; more positive attitudes about writing; and an increase in the number of students demonstrating higher order thinking skills in their writing.

- In 2004, an evaluation of a laptop immersion program at a small, rural high school in Maine identified an improvement in student motivation and interest in school; an increase in daily attendance; improved interaction among students and between students and teachers; reduced reliance on textbooks; and a belief among students, teachers and parents that the use of the laptops had improved the quality of student work and had a positive impact on student achievement. This was especially true for low achieving students. Students also experienced more personalized learning opportunities by exploring topics on their own; selecting their own areas of research; and influencing lessons through their interests.
- A study, published in 2005, explored the relationship between home and school computer use and English language arts test scores among 4th grade students in Massachusetts. The authors concluded that instructional use of computers during the writing process had a positive relationship with student performance on the essay portion of the test. However, they also found that students who use computers to create presentations during class perform worse than expected on the writing portion of the test; they theorized that students are spending class-time to create and revise multimedia presentations & therefore, spend less time writing and developing writing skills. Finally, they suggested that students who spend more time on recreational computer use at home perform worse than expected on reading & literature portion of test; likely due to less time spent reading at home.
- A 2005 literature review of 30 studies on the impact of 1:1 laptop programs concluded that the available research-based evidence is generally positive, especially with respect to technology use; technological proficiency; and writing skills.
- An evaluation of the first 9 months of a 1:1 laptop program in 6 of New Hampshire's most needy schools, published in 2005, found similar results to other studies. Teachers believed that increased computer use had led to greater student participation in class, particularly for low achieving students; higher levels of student motivation and engagement; increased ability of students to work independently and in groups; an increased level of positive interaction with other students and with teachers; an improvement in the quality of student writing; and a slightly higher ability to retain content material.
- PUSD's 2005 evaluation of the laptop immersion program at Harvest Park found that participation in the program led to an overall significant impact on student achievement as those students who had participated in the program tended to:
 - Attained higher GPAs
 - Received higher grades in English & math
 - Were more likely to meet or exceed grade level expectations on district writing assessment, offered in 6th & 8th grades

- Were more likely to score at or above national average on language & math portions of CAT 6 at all 3 grade levels
- Scored proficient or advanced on English language & math portions of the California STAR tests

Barriers to technology in schools

Despite the apparent benefits of the use of educational technology, a number of factors may hinder the effective, widespread use of technology in schools:

- Putting together an effective and well-implemented technology plan is difficult. Many believe that teacher input on technology decisions is critical.
- Without sufficient and high quality professional development for teachers, benefits of educational technology use may be negligible or minimal. Some believe that up to 1/3 of technology budgets should be set aside for professional development. This may range from informal sharing and joint curriculum planning among teachers to intensive 10-day sessions on instructional strategies and computer tools.
- Funding of the infrastructure will continue to be a major barrier, both in terms of providing a current base of technology in schools and in maintaining it. Additional difficulties arise as a result of the inequities between schools in funding of technology initiatives.
- There is a need to provide effective and ongoing support for teachers with the integration of technology into the curriculum in terms of both technical and digital content expertise as well as the necessary time for planning.
- Potential for student misuse of wireless access. Students must be taught appropriate and safe uses of technology and policies must be in place with consequences for misuse.
- Evaluations of the impact of technology on student achievement may be difficult to fully assess in direct terms such as test scores and may have to be broadened to include indicators such as discipline referrals; complexity of homework assignments completed; enrollment in more challenging courses; declines in special education placements; lower drop out rates; rises in numbers of college-bound students; and greater parent participation.
- Teacher and student standards for technological literacy/proficiency are not available and/or well developed. In many cases, students' computer literacy exceeds that of their teachers, which may lead to awkward instructional situations.
- Finally, teacher attitudes towards technology are critical. Teachers must believe that students are capable of completing complex assignments independently or with peers; that technology is a tool with a wide variety of applications; and that adequate software and internet-based resources are available to support their content area.

Summary and conclusions

Despite some limitations in the scope of the research-based evidence, there does seem to be a sufficient body of data, both quantitative and qualitative, to determine a positive relationship between increased use of educational technologies and student achievement. This is demonstrated directly, by increased scores on standardized testing, particularly in the areas of writing and mathematics; as well as indirectly through an increase in student motivation, engagement and positive attitudes toward learning. All of these are well known to be critical contributing factors to increases in student achievement. These gains in student achievement are often proven to be greater for low achieving and/or at risk students. Finally, many of the studies referenced student gains in higher order thinking skills including creative and critical thinking. Although, these are more difficult to measure, the broad range of anecdotal data, suggests that this is a credible, positive conclusion.

The provision of laptops to middle and high school students appears to be a promising approach in building technology proficiency as well as writing and other academic skills; overcoming inequities; promoting communication and collaboration; and providing higher levels of student engagement and motivation; as well as producing identifiable gains in test scores and grades.

Certain conditions must be satisfied to ensure that the gains in student achievement associated with the effective use of technology in education are realized and/or maximized. For example, a comprehensive plan must be developed that links technology with core instructional objectives. There must be sufficient funding to provide up-to-date equipment and software, to maintain it, and to train and provide ongoing support to teachers in integrating technology into the curriculum and employing appropriate instructional strategies. Technologies used should be those that promote higher order thinking rather than the drill and practice forms of software, which are less likely to prove effective. Safeguards must be put into place to protect students and the integrity of the systems. Finally, ongoing evaluations of the impact of technology must take a broader view of student achievement, beyond test scores and consider impacts on student motivation, engagement and other critical factors.

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