How Does Technology Influence Student Learning?

This month's Research Windows highlights research findings for frequently asked questions regarding technology's effects on student learning as determined by the Center for Applied Research in Educational Technology (CARET).

By John Cradler, Mary McNabb, Molly Freeman, and Richard Burchett

Subject: Research on academic performance and technology

Audience: Teachers, technology coordinators, library/media specialists, teacher educators

Grade Level: K–12 (Ages 5–18)

Technology: All

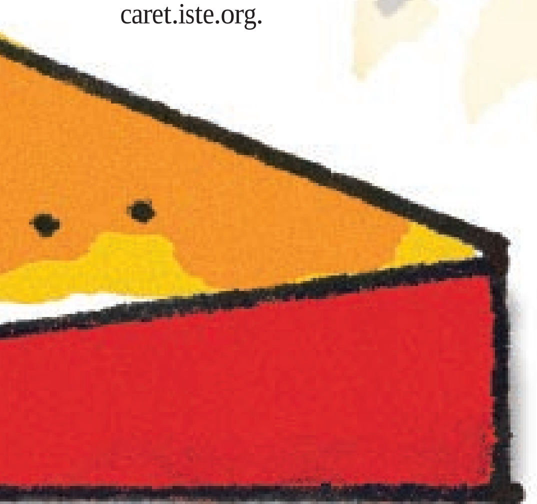
Standards: *NETS•T* II; *NETS•A* I (www.iste.org/standards)

Supplement: www.iste.org/L&L

Evidence is mounting to support technology advocates' claims that 21st-century information and communication tools as well as more traditional computer-assisted instructional applications can positively influence student learning processes and outcomes. The Center for Applied Research in Educational Technology (CARET) has gathered compelling research and evaluation findings to answer frequently asked questions about how technology influences student achievement and academic performance in relation to three primary curricular goals:

1. Achievement in content area learning
2. Higher-order thinking and problem-solving skill development
3. Workforce preparation

The research findings also emphasize the importance of using technology in conjunction with collaborative learning methods and leadership aimed at technology planning for school improvement purposes. For access to additional research findings applicable to collaboration, planning, procurement, and implementation of technology in schools, read the supplement online at www.iste.org/L&L and visit the CARET Web site at http://caret.iste.org.



Content Area Achievement

First and foremost, research reminds us that technology generally improves performance when the application directly supports the curriculum standards being assessed. In other words, making standards and learning objectives explicit to the students is part of effective technology implementation. Technology integration activities often require teachers and curriculum planners to revisit curricular standards as they select technology applications. A review of studies conducted by the CEO Forum (2001) emphasizes: "technology can have the greatest impact when integrated into the curriculum to achieve clear, measurable educational objectives."

A recent study illustrates how alignment between content-area learning standards and carefully selected technology uses can significantly increase test scores. In an eight-year longitudinal study of SAT-I performance at New Hampshire's Brewster Academy (Bain & Ross, 1999), students participating in the technology-integrated school-reform efforts (School Design Model) demonstrated average increases of 94 points in combined SAT I performance over students who participated in the traditional school experience. The reform efforts included a pioneer laptop program, where all students and faculty carry portable computers and have ready access to a campus network. Along with technology implementation, Brewster's extensive school reform efforts involved "rethinking the way we teach, how we build curriculum, and the way we support and evaluate faculty" (Bain & Smith, 2000, p. 152).

A West Virginia study shows an increase in test scores resulting from integrating curriculum objectives for basic skills development in reading and mathematics with instructional software (Mann, Shakeshaft, Becker, & Kottkamp, 1999). This curriculum was reinforced with teacher instruction and student achievement tests. Gains in student test scores on the SAT-9 (for 950 fifth graders in 18 schools) appeared attributable to the alignment of the targeted curriculum standards with the software, teacher instruction, and tests.

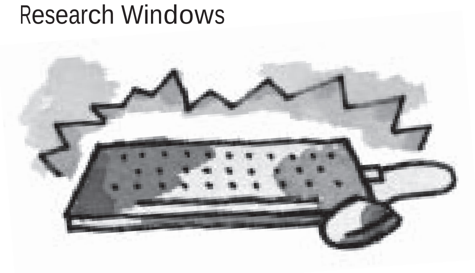
Numerous studies document student understanding of mathematics concepts from using computer-based and -assisted software. Logo programming, computer-assisted instruction (CAI) microworlds, and algebra and geometry software are among those effective in facilitating mathematics achievement for elementary, middle, and high school students when teachers are skilled in guiding student activities (Hillel, Kieran, & Gurtner, 1989; McCoy, 1996; Simmons & Cope, 1990, 1993).

In English language arts and social studies, teachers report observing significant change in student skills and knowledge acquired after their students' first multimedia project. After student completion of the first multimedia project, teachers reported increased student knowledge in:

- research skills,
- ability to apply learning to real-world situations,
- organizational skills, and
- interest in the content (Cradler & Cradler, 1999).

Higher-Order Skills Development

Higher-order thinking and problem-solving skills (e.g., information research, comparing and contrasting, synthesizing, analyzing, and evaluating) enable learners to apply their content knowledge in a variety of ways leading to innovation and deeper understanding of content domains. Though some technology applications are designed for use in specific content areas, educa-



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tors have also found valuable *thinking tools* among the technology applications available for educational purposes. Research and evaluation shows that technology tools for constructing artifacts and electronic information and communication resources support the development of higher-order thinking skills. The findings hold true when students are taught to apply the processes of problem solving and then are allowed opportunities to apply technology tools to develop solutions.

Powerful technologies are now available to significantly augment the skills necessary to convert data into information and transform information into knowledge. For example, interactive video programs have been demonstrated to increase problem-solving skills. Students across nine states who used Jasper video software as a centerpiece for mathematics instruction for three to four weeks were compared with students who did not. The comparative research demonstrated that the students in classrooms who used the Jasper video programs were better able to complete complex problem-solving tasks (Cognition and Technology Group, 1992).

In Pittsburgh, Pennsylvania, an intelligent-tutor software program, as part of the regular curriculum for ninth-grade algebra, supports a curriculum focusing on mathematical analysis of real-world situations and the use of computational tools. "On average, the 470 students in the experimental classes using the software outperformed students in comparison classes by 15% on standardized tests and 100% on tests targeting the curriculum-focused objectives" (Koedinger, Anderson, Hadley, & Mark, 1999, p. 1). It is important to note, however, that students may manipulate simulation and presentation software to create a visual artifact without really understanding or applying sound conceptual thinking. The role of teachers is paramount in guiding the development of students' higher-order thinking skills during learning activities involving technology tools.

In a landmark study analyzing a national database of student test scores, Wenglinsky (1998) determined that technology can have a positive effect on students' mathematics scores. His study used data of fourth- and eighth-grade students who took the math section of the 1996 National Assessment of Educational Progress (NAEP). That NAEP included questions about how computers are used in mathematics instruction. After adjusting for class size, teacher qualifications, and socioeconomics, Wenglinsky found that technology had more of an impact in middle schools than it did in elementary schools (Valdez et al., 1999). In eighth grade, where computers were used for simulations and applications to enhance higher-order thinking skills, the students performed better on the NAEP than did students whose teachers used the technology for drill and practice. "He found that fourth-grade students who used computers primarily for 'math/learning games' scored higher than students who did not. … fourth graders did not show differences in test score gains for either simulations and applications or drill and practice" (Valdez et al. 1999, p. 24).

Another study of 22 fourth- and sixth-grade classes in seven urban school districts involved 66 of the participating students in a civil rights curriculum using online communication and the Internet. The control group of 38 students did use the computer but did not use the online resources with the curriculum. Center for Applied Special Technology (CAST) researchers assessed the effect of Internet use on student performance by looking at the benefits it had on student projects. According to the CAST (1996) researchers, "students with access to Scholastic Network and the Internet produced better projects than students without online access." Of the nine measures of performance, the online users received significantly higher scores relative to:

- presenting their work,
- stating a civil rights issue,
- presenting a full picture (who, what, when, where, why, how),
- bringing together different points of view, and
- producing a complete project (CAST, Table 2).

Research and evaluation shows that technology can enable the development of critical thinking skills when students use technology presentation and communication tools to present, publish, and share results of projects. The CAST study also found that when students used the Internet to research topics, share information, and complete a final project within the context of a semi-structured lesson, they became independent, critical thinkers (Coley, Cradler, & Engel, 1997).

Using technology tools to build thinking skills is not just for the best and brightest students. The Higher Order Thinking Skills (HOTS) pull-out program, developed in the early 1980s to build the thinking skills of students, combined technology with drama and Socratic dialogue. Through this combination, disadvantaged students in Grades 4–7 achieved twice the national average gains on reading and math test scores. Ten to 15% of the students also achieved honor roll status in 1994, suggesting a transfer of the students' cognitive development to learning specific content. The students who used HOTS also increased performance on measures of reading comprehension, metacognition, writing, components of IQ, transfer to novel tasks, and grade point average (Coley et al., 1997; Pogrow, 1996).

Workforce Preparation

Preparing students for the workforce is a third area where technology plays a pivotal role in helping school communities reach their educational goals. Research shows that when students learn to use and apply applications used in the world of work, such as word processors, spreadsheets, computer-aided drawing, Web site development programs, and the Internet, they acquire some of the prerequisite skills for workforce preparedness. When content and problem-solving strategies meet accepted education standards, technology increases mastery of vocational and workforce skills and helps prepare students for work (Cradler, 1994).

Integration of technology with thematic and interdisciplinary projects can enhance career preparation. A study of four health career programs in California (Stern & Rahn, 1995) demonstrated the effectiveness of work-based learning models such as Tech Prep and career academies that integrate students' work experience with academic subjects such as math, English, science, and social studies. These programs allow high school students to gain valuable knowledge about how to conduct themselves in actual workplace environments. Reflection is an essential part of these work-based learning programs where teachers integrate a health care theme into academic assignments or interdisciplinary projects. For example, the math teacher in one program encourages students to analyze forces and angles in physical therapy, design a building to house a health clinic, and determine the amount of money a medical assistant must save in five years to pay for college tuition.

Technology can be useful in linking work experiences with academic subjects. In a nationwide review of school-to-work programs, Olson (1998) found programs where students were learning the *new basics* or *basics plus* skills. These skills include the ability to use technology to communicate ideas and information orally, as well as in writing. The new basics also include working in groups, solving problems when answers aren't always self-evident, understanding how systems work, and collecting, analyzing, and organizing data. In a report on the state of technology integration in Minnesota, schools document the benefits of using information technologies to bring the world of work into the classroom (Johnson, 1996).

Conclusion

The research and evaluation studies cited in this article represent highlights from a larger body of evidence reviewed by CARET and available online. In sum, research is providing more and more clarity about how to use technology effectively within our school communities to support and enhance the academic performance of today's youth. Collaborative activities and formative feedback are key components of instructional strategies that accompany effective technology implementation. Leadership also is pivotal in aligning available technology resources with systemic school improvement goals. The research indicates the need for understanding the combined efforts necessary for technology to positively influence students' academic performance. (For more on the roles collaboration, leadership, and technology planning play, see the article supplement online at www.iste.org/L&L.)

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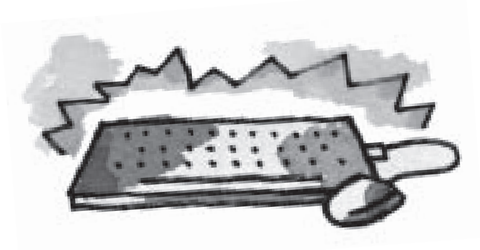

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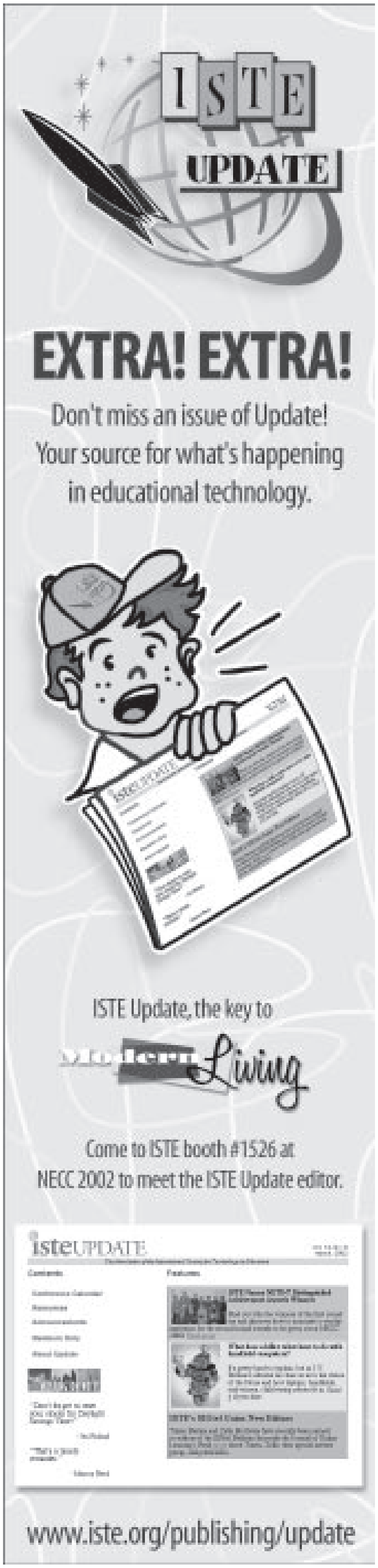

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