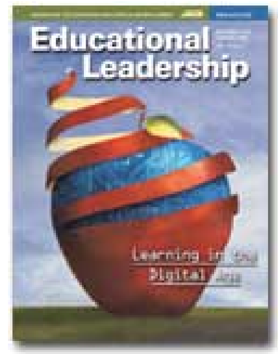
EDUCATIONAL LEADERSHIP

December 2005/January 2006 | Volume **63** | Number **4**
Learning in the Digital Age Pages 48-53



December 2005/
January 2006

Tools for the Mind

Why are schools using computers primarily to teach low-level skills when technology has the potential to deepen student learning?

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Revisiting the literature from the 1990s on instructional technology is like journeying back to a more nostalgic and hopeful time when the promise of computers—and their potential impact on student learning—appeared boundless. Used in concert with a learner-centered instructional approach and a curriculum that focused on authentic learning, computers, it was thought, would serve as "mind tools" (Jonassen, 1996) to build students' higher-order thinking skills. In fact, the terms *computers* and *higher-order thinking* formed a sort of double helix in instructional technology parlance. Infrastructural supports in the United States—such as E-rate and federal funding for hardware, software, and teacher training initiatives—exemplified a commitment to the belief that computers could transform student learning.

How different the present era. With proposed budget cuts for teacher technology training programs, the mandates of NCLB, and, most important, no body of research unequivocally linking student technology use to improved learning, the pendulum has shifted. Computers will certainly not disappear from schools, but educators and education officials are currently scrutinizing their potential value as an instructional tool.

This diminished enthusiasm may prove beneficial in the long run. By reflecting on the original goals for instructional technology and reevaluating prevailing patterns of classroom technology use, we can begin to bridge the gap between intention and implementation.

What Happened to Eureka?

Can technology improve student learning? Yes. Computers can provide transformative student learning experiences that would otherwise not be possible. One such moment occurred during an activity I conducted with social studies teachers, in which they were tasked with reapportioning the 435 members of the House of Representatives across the 50 states using 2000 Census population data. Although these teachers "covered" reapportionment in the curriculum, they had never really understood its impact nor the impact of the Connecticut Compromise on each state's share of electoral votes—until they used spreadsheets to model reapportionment. They realized that each person's vote is weighted differently, depending on the state in which he or she lives. People living in states with smaller populations have a larger share of the vote than do residents in more populous states.

Why are such *eureka* moments the exception rather than the rule? Many educators believe in the “exceptionality” of computers, viewing them as instructional talismans that can do for student learning what other reforms and tools cannot. This has resulted in a narrow focus on technology at the expense of the more important pillars of learning—cognition, instruction, assessment, and curriculum. Four common behavior patterns reinforce this notion of exceptionality and simultaneously handicap the potential of computers to promote higher-order thinking.

First, many districts have concentrated on professional development that trains teachers in skills instead of teaching them how computers can enhance student learning. This focus on technology skills has diverted needed attention from helping teachers understand the instructional practices best suited to capitalize on technology's potential, serving instead to hide or exacerbate weaknesses in instruction, lesson design, and assessment.

Second, many districts have not made the kinds of accommodations necessary to allow for the full capitalization of classroom technology, failing to provide such supports as long-term professional development in technology integration; access to sufficient hardware and software; creation of sufficient instructional time for inquiry-based, technology-integrated activities; on-site technical support; and instructional leadership to help teachers understand how they can use computers to extend and deepen student learning.

Third, schools have conflated technology use with instructional quality and student engagement with improved learning and higher-order thinking. In all the excitement about new ways of teaching with technology, we educators may have neglected to pose the most fundamental question: Are students really learning?

Fourth, we often classify all software applications as cognitively and instructionally equal. This misconception has resulted in an overreliance on conceptually easy kinds of software—lower-order applications that, although engaging, focus on simple cognitive tasks—at the expense of more conceptually difficult kinds of software—higher-order applications that are more aligned with higher-order skills.

Lower-Order Versus Higher-Order Applications

Technology alone cannot move students to higher-order thinking skills, but some applications are more suited for this task than others. My own experience in classrooms indicates that students generally use lower-order applications that offer few opportunities for problem solving, analysis, and evaluation.

Observations of middle and high school classrooms conducted between 1999 and 2003 through the South-Central Regional Technology in Education Consortium indicate that most schools use the Microsoft Office software suite (including word processing, spreadsheet, database, electronic presentation, publishing, Web editing, and e-mail programs) as well as the Internet. As Figure 1 illustrates, the most commonly used applications are what I call show-and-tell applications—PowerPoint, Word, Publisher, and Front Page—with the Internet the most commonly used non—show-and-tell kind of application in terms of frequency of classroom use. Classrooms rarely use spreadsheets or databases, which are conceptually and technically more difficult. E-mail is virtually nonexistent because of policies prohibiting student use.

Figure 1. Frequency of Classroom Technology Use

Electronic presentation:	81 percent
Word processing:	68 percent
Internet:	50 percent
Publishing:	40 percent
Web editors:	36 percent
Spreadsheets:	6 percent
Databases:	<1 percent
E-mail:	<1 percent
These data were gathered from 247 observations of classroom technology use from 1999 to 2003 in 10 low-income middle and high schools. The observations were conducted through the SouthCentral Regional Technology in Education Consortium. Percentages are based on classroom observation and teacher self-reports.	

The ability to synthesize information using a combination of text and visuals is certainly an important skill. But an overreliance on electronic presentation software precludes more rigorous kinds of learning. PowerPoint does not lead students to delve deeply into the writing process or wrestle with complex and conflicting conceptual information. Indeed, its very architecture demands episodic, disjointed knowledge construction. Content is reduced to a “sight bite”; the focus is on color and visual stimulation. PowerPoint may be developmentally appropriate for younger students who are still learning the refinements of organizing thoughts. It may be a wonderful entry-level tool for teachers wading into the technology waters. But as the default tool of choice at the middle and high school levels, it fails to promote deep, complex, or even developmentally appropriate learning.

In addition to lower-order tools, classrooms use more robust tools, such as the Internet, in such nondifferentiated ways that they dilute their power. Although students use the Internet to access information, I have seen little evidence of students engaging in more complex and dynamic kinds of online learning opportunities—such as online collaboration or content-oriented simulations—despite the fact that much of the rationale for broadband access in schools was for students to take part in such opportunities.

Instead, students generally use the Internet as an electronic textbook, often without questioning, validating, or evaluating the information they find. Consequently, a good deal of student Internet use is intellectually passive, with the greatest amount of activity occurring at the fine motor level—pointing, clicking, and copying and pasting large amounts of text (often with impunity and without attribution) into Microsoft Word, PowerPoint, or Publisher, a pattern emblematic of an increasingly copy-and-paste culture (Gibson, 2005).

More developmentally appropriate and challenging tools, such as spreadsheets and databases, offer richer opportunities to practice analytical and critical thinking skills. Spreadsheets demand both abstract and concrete reasoning and involve students in the mathematical logic of calculations. They enable learners to model complex and rich real-world phenomena. Students practice their critical thinking skills by making assumptions, coding assumptions as variables, manipulating variables, analyzing outcomes, and evaluating and displaying data both quantitatively and visually (Jonassen, Carr, & Yueh, 1998).

Yet how do classrooms generally use spreadsheets? For show-and-tell: to input and graph information. Although spreadsheets are a natural fit for math and science classes—as the various Excel applications, from accounting to trigonometric function, illustrate—they are often conspicuously absent from these environments. Spreadsheets may receive their most rigorous workout in computer classes, but often in a decontextualized, mechanical fashion (entering data, formatting columns, and so on)—a lower-order use of a potentially higher-order tool.

Databases, like spreadsheets, are naturally suited to cultivating higher-order thinking skills. By its very taxonomical nature, database design can help students systematically organize, arrange, and classify data according to established criteria (Adams & Burns, 1999). Such activities require students to think inductively (in aggregating data) and deductively (in disaggregating information). Yet databases, like spreadsheets, are “difficult,” so students rarely use them for analytic purposes.

A number of other software tools offer even greater opportunities for interacting with rich content, real-world data, and complex procedures that foster higher-order thinking. These tools are nearly invisible in most schools. Geographic information systems (GIS), computer-aided design programs, and simulation software programs—especially those with a problem-based component—can stimulate students' intellectual development and enable learners to create, revise, and reconstruct what they know to create new frameworks of knowledge.

For example, students can use GIS to indicate a geographic area's vulnerability to natural disaster, identifying constraints such as floodplains or areas subject to coastal erosion. They can create an alternative land use plan in light of such constraints. Using a free GIS-type tool, such as Google Earth, they can show change over time for a specific city by scanning in historical photos of the city and “rubber-sheeting” them onto the actual topography of a current satellite view.

Why, then, the focus on lower-order technology tools at the expense of higher-order ones? Why the near ubiquity of PowerPoint and the dearth of databases? Higher-order tools, for the most part, are not as user-friendly or visually appealing. They are time-intensive to learn, integrate, and use. Teachers often don't understand how these applications can help foster analytic skills because they don't understand the tool or its instructional possibilities. Similarly, school districts often lack technology trainers who are proficient in the mechanics of these tools and in the conceptual skills they demand. It's easier, quicker, and cheaper to teach and use PowerPoint. It's easier to ask students to write a newsletter article in Publisher that explains the Connecticut Compromise than to require them to use spreadsheets to model the way in which the Connecticut Compromise influences the notion of “one person, one vote.”

Two Strategies for Change

How can schools and school districts change such patterns of use and nonuse and address the factors that impede teachers from capitalizing on computer technology's instructional potential? It will require a return to original assumptions—the need for critical thinking, for learner-centered instruction, and for students to use computers as mind tools. It will also require professional development for teachers that systemically and intensively addresses these needs (Boethel & Dimock, 1999; Means et al., 1993; Roehrig-Knapp & Glenn, 1996).

Strategy 1: Teach critical thinking first and technology later.

If higher-order thinking is a main goal of instruction, then teachers themselves must keep sharpening their critical thinking skills. It's not enough to help students find and communicate information. Teachers need to show students how to evaluate the information's veracity, reason logically, come to evidence-based decisions, create relevant new knowledge, and apply this learning to new situations. This instruction may involve using computers, but computer use is not the goal. Students may be engaged, but engagement is not the goal, either. Students and teachers must become *creators* of information and ideas, not simply users of technology.

For example, a science teacher might ask students to create a survey that measures attitudes about the environment, which they would administer to teachers, peers, and community members. Students could input survey responses in Excel and run a basic statistical analysis of the data, thereby creating two new sets of information: survey data, and an analysis of survey results. Or students could deconstruct hard-copy graphs, examining their scale, proportion, labels, graph types, units of measure, clarity of message, and data integrity. By doing so, they would familiarize themselves with the idea that every graph tells a story, using numbers to stand in for words.

For students and teachers to become creators of information, the instructional technology community needs to focus on the role of computers as learning tools. In our desire to advance technology use among teachers, those of us working in the field have often resorted to cheerleading as opposed to critical thinking, rationalization as opposed to reasoning, and complacency as opposed to critical self-reflection regarding patterns of current classroom computer use. The instructional technology community needs to actively encourage teachers to reflect on technology and engage them in discussions about technology's role in fostering learning.

Teachers should reflect on the following questions:

- What kinds of software should I use in the classroom, and why?
- When should my students use computers in class? When should they not use them?
- Does the current technology use in my classroom support the curriculum and deepen content? How?
- Do certain uses of technology match certain learning outcomes?
- Does my current technology use improve my students' learning?

More specific questions might deal with how teachers could use spreadsheets to help students better understand linear algebra, what kinds of communications skills students might develop if they heavily use PowerPoint, or how Microsoft Word might help improve student writing in ways that would otherwise be impossible.

Strategy 2: Focus on curriculum, instruction, and assessment.

So much current technology professional development for teachers is stalled at the sensorimotor stage (Piaget, 1936)—focusing on tool use instead of on critical evaluation of the tool's ability to achieve stated education aims. Professional development must foster an intellectual environment in which teachers address not just the lower-order *what* and *how to* questions that accompany technology professional development, but also the higher-order *how* and *why* questions that prompt real understanding of the true potential of computers in instruction.

To use and integrate computers in higher-order ways, teachers must engage in intensive and ongoing professional development that responds to a number of needs. First, the program should model good instruction and take teachers through the learning process so that they experience learning from the learner's point of view and reflect on it as a practitioner. For example, in Southwest Educational Development Laboratory's Active Learning with Technology program, teachers participate as students in ongoing problem- and project-based activities that feature technology as a problem-solving tool. They then reflect on these activities as teachers and plan similar exercises in their own classrooms.

Second, professional development should help teachers understand the conceptual reasoning behind such higher-order software as geographic information systems and databases. For example, in learning about geographic information systems, teachers can begin by working with a series of base maps, transparencies, and vellum grids. Teachers can take a sheet of transparency, overlay it on the base map, and color in features. They can add or remove layers by adding or removing transparencies. In this way, they become familiar with the concepts of spatial analysis and overlaying information, and they come to understand the importance of scale and projection.

Third, professional development should model technology use that is deliberately matched to a particular learning outcome so that teachers can see how activity design, tool use, and learning connect. For example, teachers could go through a structured exploration of various kinds of software—from those that emphasize “drill-and-kill” to more open-ended products—in light of Bloom's Taxonomy. This kind of analysis would reveal that not all software is equal. Some products are good for lower-order skills and some for higher-order skills.

Last, professional development should focus on core areas of teaching—content knowledge, curriculum, instruction, and assessment. Once teachers have a solid base in these areas, they can begin incorporating technology. Teachers should familiarize themselves with the skills needed to manipulate specific software applications, but the focus should be on integrating technology to support the four core areas of teaching. The technology should be almost invisible. Also, training should help teachers overcome their concerns about not being experts in technology use. They will develop their expertise as their students do, in time and with practice.

To implement these recommendations, teachers need a panoply of supports. They need opportunities to work together with colleagues to plan rich, preferably interdisciplinary activities in which technology serves to extend learning in ways that would not be possible without its use. They also need effective instructional and technology leadership from school and district administrators, access to higher-order technology tools, time to learn about and integrate these tools, and follow-up support and coaching.

The jury is still out on the impact of computers on student learning. But before we dismiss computers as an expensive fad or boondoggle, schools must take measures to ensure that they are using computers to their fullest instructional potential. Only then can we reclaim the optimism that greeted technology's dawn in the classroom. Only then will we witness the good work that results when schools use good tools well.

Techno-Byte

> Schools spent an average of $103 per pupil for education technology in 2005. In “a huge shift,” the focus of technology spending is moving away from instructional technologies and toward data-management technologies to meet the expansive reporting requirements of No Child Left Behind.
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> —*Technology Counts*, 2005

References

Adams, S., & Burns, M. (1999). *Connecting student learning and technology*.

Austin, TX: Southwest Educational Development Laboratory.

Boethel, M., & Dimock, V. (1999). *Constructing knowledge with technology: A review of the literature*. Austin, TX: Southwest Educational Development Laboratory.

Gibson, W. (2005, July). God's little toys: Confessions of a cut and paste artist. *Wired*, 118–119.

Jonassen, D. H. (1996). *Computers in the classroom: Mindtools for critical thinking*. Englewood Cliffs, NJ: Prentice-Hall.

Jonassen, D. H., Carr, C. S., & Yueh, H-P. (1998). Computers as mindtools for engaging learners in critical thinking. *TechTrends, 43*(2), 24–32. Available: http://tiger.coe.missouri.edu/~jonassen/Mindtools.pdf

Means, B., Blando, J., Olson, K., Middleton, T., Morocco, C. C., Remz, A. R., et al. (1993). *Using technology to support education reform*. Washington, DC: U.S. Department of Education.

Piaget, J. (1936). *The origins of intelligence in children*. New York: W. W. Norton & Company.

Roehrig-Knapp, L., & Glenn, A. D. (1996). *Restructuring schools with technology*. Boston: Allyn and Bacon.

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