

CHAPTER 10

Technology's Greatest Value

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The educational materials developer William Pflaum (2004) wanted to witness the ways technology in schools had transformed education. He visited a cross-section of schools across the nation, observing classrooms and talking with teachers, students, technology specialists, and administrators. His book, *The Technology Fix: The Promise and Reality of Computers in Our Schools*, records his findings.

Pflaum was mostly disappointed by what he saw. Among his conclusions, he noted that teachers know how to use productivity tools but the skill “does not necessarily carry over to the effective use of computers for instruction.” He also noted that “too much time is spent on the mechanics of computer-based tools and too little time is spent on the content being studied” (pp. 196–197). He placed the types of computer use he observed into five categories:

- ▶ **Computer as Teaching Machine.** Pflaum observed in a few classrooms students using “skill-building games, intervention activities, simulations, and test-prep materials” (p. 190), mostly in lower grades and often, in his opinion, ineffectively. With rare exception, the computer when used this way was intended to temporarily relieve the teacher of some teaching task.
- ▶ **Computer Productivity Tool.** Most often, especially in middle schools and high schools. Pflaum found students using computers as a “report writer, presentation giver, digital graphics tool, and communications hub.” In some cases, teachers were convinced that the PowerPoint presentations students created taught them much about the target content, but most often student thought and energy seemed to be going into “exploring the mechanics of the software instead of the content” (p. 192).
- ▶ **Computer as Internet Portal.** Pflaum saw some teachers using the internet to give students access to information—sometimes information “they could not

have found within any school's four walls" (p. 193). In some cases students used the web to capture images and sound files to place in their PowerPoint presentations. The most "exceptional" activity he observed was students creating their own web pages based on the material drawn from a list of prequalified websites.

- ▶ **Computer as Test Giver.** Infrequently, Pflaum observed schools using computer-based testing. He saw this use as most attractive for high-stakes assessment because it allows for quicker reporting of results.
- ▶ **Computer as Data Processor.** A few administrators Pflaum spoke with viewed the primary role of computers as providing the data that drove their curriculum and administrative decisions.

In essence, Pflaum's investigation revealed schools as places where computers are ubiquitous, but are used primarily for administrative tasks and low-level instruction that emphasizes traditional instructional approaches. Although his work consists of unsystematic observations and anecdotes, Pflaum's findings largely parallel the research findings of Larry Cuban's (2001) earlier investigation. Technology in schools has, at best, tended to support traditional instruction, rather than rising to its potential to transform the ways teachers teach and students learn. At worst, technology in schools has been relegated primarily to administrative tasks, with little or no impact on classroom instruction.

A series of studies by the Pew Foundation on the Internet and American Life has systematically documented the way in which technology is affecting society and schools. In contrast to the somewhat pedestrian uses of technology in schools, these studies report that students are using technology extensively and in innovative ways outside of school. The authors conclude that there is a "digital disconnect" between limited use of technology in schools and extensive use of technology by students to complete academic work outside of school.

Using Technology Effectively in the Science Classroom

In contrast to technology uses Pflaum observed, this monograph describes a vision in which technology is used to facilitate data collection and analysis, to enhance scientific understandings through imagery and visualization, and to extend inquiry through communication and collaboration. Many of these uses of technology in science instruction are supported by a solid base of research evidence showing their value for improving student understanding.

The technology uses described here are powerful and effective because they follow a common philosophy, explicit in many of the individual chapter guidelines for best practice and implicit in the example activities. In general, these guidelines

and examples emphasize

- (1) keeping the focus on the science content rather than the mechanics of the technology;
- (2) using technology in ways that are consistent with appropriate pedagogy, including opportunities for inquiry learning;
- (3) using technology in ways that allow teachers and students to do what would otherwise be difficult to do without technology; and
- (4) taking advantage of technology's power to engage student participation and interest.

Essentially, technology use in the science classroom is most effective when it encourages deeper student engagement with science content, when it is used to support rather than replace what we know about effective science instruction, and especially when it stretches the boundaries of what is possible in the science classroom.

Inquiry and Technology

A national consensus has established the central role of inquiry in science education. In fact, the National Science Education Standards (NSES) place inquiry “at the heart of science and science learning” (NRC 1996, p.15). As described in the NSES, inquiry into student-generated questions is a fundamental strategy for teaching science.

When thinking of inquiry, most teachers focus on real phenomena, whether in classroom instruction, in laboratory settings, or outdoors. The individual chapters of this book present a range of ideas and strategies supporting inquiry into real phenomena in each of these settings. However, as students engage in more abstract and complex topics, they soon reach the point at which exploring real phenomena is impractical or even impossible. This is the point at which the capabilities of computer-based technologies stand out. Teachers can engage students in inquiry as they guide students in acquiring and interpreting information from secondary sources, including internet databases and computer simulations.

Still, the way in which these resources are used is critical—using the internet as a convenient source of authoritative information is no better than using the textbook as the final authority. Neither approach emphasizes scientific inquiry as a powerful way to build knowledge.

In addition to *doing* inquiry, the NSES also emphasize developing understandings *about* inquiry as an essential component of scientific literacy. Thus, students should not only learn how to perform and design scientific investigations, but they should learn scientific habits of mind and the variety of ways scientists approach their investigations. Unfortunately, textbook approaches to science instruction of-

ten lead students to see scientific inquiry as an algorithm—the mythic “scientific method.” Students dutifully learn the “five steps” of the scientific method as if it were a creed. Yet, scientific inquiry is so much richer than any algorithm!

Appropriate uses of technology have the potential to let students experience and learn about a wide variety of approaches to scientific problem solving. As the resources provided in this book demonstrate, technology in the hands of creative teachers can expand the range of ways students see science and experience first-hand the joy of discovery and the creative thinking that goes into planning investigations. By experiencing the creative, problem-solving side of scientific work, they are more likely to see scientific investigations as relevant or meaningful. Thus, in the hands of a skillful teacher, computer-based technologies can provide students with an interactive, educational environment for both thinking about and doing scientific investigations.

The Unnatural Nature of Science

One major challenge of science instruction is that many scientific ideas are complex, abstract, and contrary to everyday experience, making them difficult for students to understand. As Wolpert (1992) explained,

I would almost contend that if something fits in with common sense it almost certainly isn't science. The reason again, is that the way in which the universe works is not the way in which common sense works: the two are not congruent. (p. 11)

The large body of literature on misconceptions supports the idea that learning science is neither straightforward nor consistent with students' everyday experiences (e.g., Driver et al. 1994). These nonintuitive ideas present science teachers with pedagogical challenges. Developing the skills for making scientific views more accessible is an example of “pedagogical content knowledge” (Shulman 1987). Teachers, Shulman argued, may be distinguished from other professionals by their ability to link knowledge of content, instruction, learners, and curriculum.

As the chapters in this book have shown, technology provides unique opportunities to address these challenges, but only when used in conjunction with effective teaching practices. Technology use can be seen as a means to an end (student learning), but never the end in itself. The bottom line is that it's not about the technology. It's about how teachers use the technology. Even with all of the promising new technologies available today, the teacher is still (and always will be) the most important part of the equation.

Scientific Information and the Web

Much of the knowledge people use every day is closely linked to science and the ways scientific knowledge is produced. They use this knowledge to solve problems creatively, think critically, work cooperatively in teams, and use technology effectively. In fact, one indicator of scientific literacy is the ability to use scientific principles and processes in making personal decisions (NRC 1996).

Evolving information technologies are presenting opportunities for more people to incorporate science in their everyday lives. The Pew Foundation (Horrigan 2006) reports that fully 87% of online users (128 million adults) have made use of the internet to conduct research on a scientific topic or concept. The positive aspect of this finding is that users are interested in science and in making use of the internet to pursue this interest—over half have used the web to check a scientific fact or statistic, and nearly as many have downloaded scientific data, graphs, or charts from the internet.

However, the conclusions of this study also suggest that happenstance is currently a significant factor in the sources of this information and the way in which it is acquired on the internet. Science educators could clearly make important contributions in preparing young citizens to use this evolving resource effectively.

Looking Ahead

The technologies discussed in this monograph were chosen to cover a cross-section of contemporary tools that were accompanied by research evidence indicating they help students engage in relevant learning of important science concepts. In the brief span of time from conception to publication of the monograph, new web capabilities have swept a generation of computer users into an era that has been characterized as an *Age of Participation*.

As the Pew Foundation has documented, 21st-century users are creating and disseminating content through a variety of internet channels that did not previously exist. These media include text (e.g., web logs, or blogs), sound (e.g., podcasts), images (e.g., Flickr), and video (e.g., YouTube). These activities are facilitated by the integration of data gathering sensors in a variety of mobile devices—digital cameras, cell phones, handhelds, GPS devices, and MP3 players. Many of these devices embody multiple functions. For example, many MP3 players can record as well as play sound, and it is increasingly common for cell phones to include digital cameras, GPS sensors, and video recorders. These handheld devices are portable digital data acquisition and communication devices, the least powerful of which has more computing power and memory than the mission control mainframe that guided the first trip to the Moon!

These activities are fueled by an emerging generation of Web 2.0 tools and technologies now available at no cost or low cost to consumers. These capabilities

increase the usability and decrease the cost of technologies discussed in this monograph. For example, MotionBox, JumpCut, and VideoEgg offer free websites that let people upload, store, and edit videos with such features as transitions and captioning. As the web itself becomes a platform, schools will not always need to purchase expensive site licenses and install software applications on every computer. Students (and teachers) can have access to their digital video projects anytime, anywhere they can get to a computer and an internet connection.

It remains to be seen if and how these capabilities can be harnessed to engage students effectively in relevant science learning. Creative science teachers may discover ways to use for science purposes the data acquisition capabilities in many cell phones. Or they may even figure out how to take educational advantage of students' interest in photographing and filming themselves—as evidenced through the popularity of sites like MySpace and Facebook—and posting their thoughts and opinions on blogs.

Technology is changing at such a rapid pace that you can be sure that even more new capabilities will arise before you have figured out all the ways to use the tools presented in this book. Indeed, the main value of this book may be in helping you form a philosophy for determining when bringing technology into the science classroom is worthwhile and a set of principles to guide you when you deem it so.

Digital technologies are so pervasive in the practice of science that to ignore them altogether would be unfair to students growing up in the 21st century. Scientists certainly use technology for writing reports, giving presentations, and communicating with others. Yet, technology's greatest value has been in helping scientists make incredible leaps in understanding the world around them. Technology at times may also serve the same purpose for your students. There will always be a cost in dollars and in time when you bring technology into the classroom, but we hope we have given you some tools for determining when the cost is worth the learning that will result.