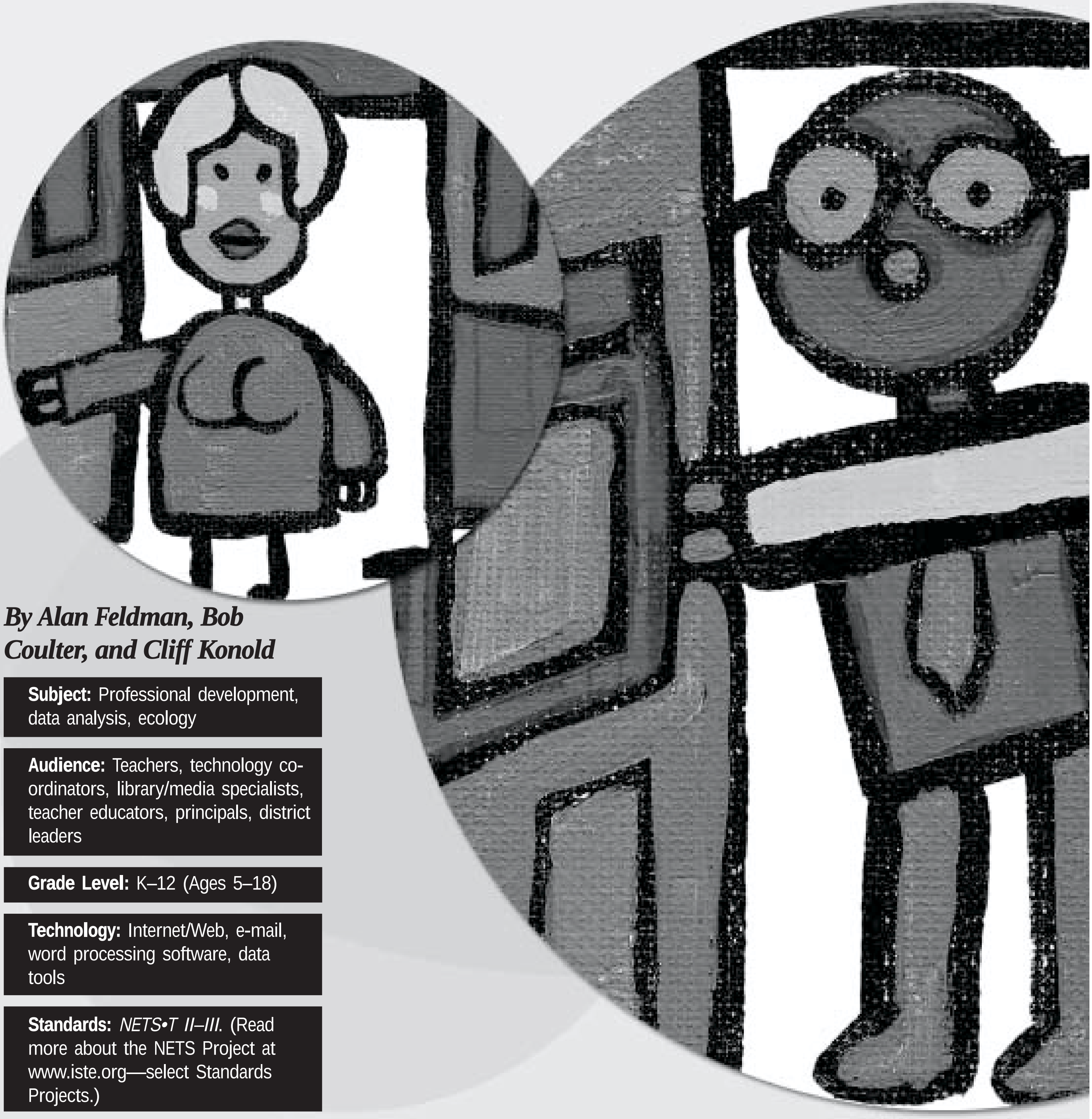
Linking Technology, Learning, and School Change



By Alan Feldman, Bob Coulter, and Cliff Konold

Subject: Professional development, data analysis, ecology

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

Grade Level: K–12 (Ages 5–18)

Technology: Internet/Web, e-mail, word processing software, data tools

Standards: *NETS•T II–III.* (Read more about the NETS Project at www.iste.org—select Standards Projects.)

Computers and Internet connections are rapidly becoming commonplace in schools, yet it is widely acknowledged that they have not had the significant impact on teaching and learning that many had expected (Kirkpatrick & Cuban, 1998). We culminate our four-article series by describing our views on how teaching practices need to change to take advantage of rapidly emerging technologies. (See More on Science and the Internet, this page.) We address two questions:

1. When a school integrates technology thoroughly into teaching and learning, what does a classroom look like and how is student learning extended and deepened?
2. How can a school or district support teachers in their integration of technology into teaching and learning practices?

To get at these answers, we begin by looking at how teaching and learning evolved in one teacher's classroom as he integrated technology and at the roles the school and district played in encouraging and supporting this transformation. This vignette focuses on science and math learning in a class taught by William, a composite character based on elementary school teachers with whom we have worked.

William is a skilled teacher, and his fourth-grade students are actively engaged in learning about science. Initially, technology plays a limited role in his classroom. We come back three years later and describe how teaching and learning practices have evolved in William's classroom through the integration of technology and the support of the school's educational technologist.

Inquiry-Based Teaching and Learning

William is a well-respected teacher at Brookside Elementary School with more than a decade of experience. Like many other teachers, he has taught every subject, but in recent years he has specialized in math and science.

Until William attended a summer workshop on ecology two years ago, he and his students knew little about the rich diversity of life in the area immediately surrounding the school. Now, each spring, William's class stud-

More on Science and the Internet

This article is the fourth based on the recently published book, *Network Science, A Decade Later: The Internet and Classroom Learning* by A. Feldman, C. Konold, and B. Coulter (Erlbaum, 2000). The authors' research focused on science curricula that use online communities and shared sets of data to support students learning science. Funded under grants from the National Science Foundation (RED-9454704, RED-9155743, and REC-9725228), their research examined the goals of these curricula and the actual experiences of teachers and students. Rather than seeing the Internet as a certain road to educational reform, the authors found that the Internet's greatest effects are felt in classes where teachers and students are already engaged in inquiry-based methods of teaching and learning. For more information about the book, see http://teaparty.terc.edu/book/.

ies wildlife in the vicinity. The ecology unit is integral to his goal of helping students appreciate the local environment and learn the interrelations of species in a given area, along with some basic plant and animal taxonomy.

Drawing ideas from a variety of curriculum guides including *Schoolyard Ecology* (from GEMS) and *Eco-Inquiry* (from the Institute of Ecosystem Studies), William bases his unit on the question, "Who lives with us here at school?" He begins with the students working in teams to identify plants and animals. William has structured the field investigations to satisfy various district-mandated science goals relating to ecology, biology, and geology. Perhaps less obvious are his activities designed to fulfill district-mandated math goals relating to measurement and area, including estimating the sizes of animals and comparing them to data in the field guides as well as measuring their study site.

The students enjoy having the outdoor sessions as part of their class work. Because they are engaged in their learning (thanks to William's careful structuring of the student groups), discipline problems are rare. The students work well in their assigned roles and take responsibility for figuring out when and how to use available equipment: hand lenses, field guides, measurement tools, and research journals. Following their fieldwork, they discuss and share their findings as a class. In their weekly computer class, students work with the school's computer coordinator to search for online science references and make use of ecology simulations. Though these simulations do not advance key curriculum goals, they are popular with the students.

The ecology unit culminates in students creating museum-style displays that detail the life forms present in each area of the schoolyard. On presentation day, the classroom is filled with pressed leaves, photographs of animal tracks and local birds, and terraria housing pill bugs and other insects. Because each team of students has been assigned to a different part of the grounds, the sharing session highlights the diversity of habitats within the schoolyard.

Despite the many compliments from his principal, parents, and colleagues, William thinks that the presentations are too formulaic, lacking the excitement that motivated his use of the student investigations in the first place. Furthermore, he is looking for ways to extend his students' understanding of ecology well beyond what they can learn from studying their local site.

Technology Supports Inquiry-Based Teaching and Learning

During the next three years, as William continues to grow as a teacher, he defines a clear goal to help him shape his curriculum: He wants his students to develop a broader and deeper understanding of ecology. As part of this strategy, he enlarges the set of resources available to students, including many posted on the Internet. He is aided by Karen, the educational technologist who joined the staff two years ago when the district replaced the role of computer coordinator. Karen has been working one-to-one with many of Brookside's teachers to co-plan lessons and co-teach when new activities are introduced on the computer (e.g., using new software or Web resources).

Recognizing the strengths and questions that William already brought to his teaching, Karen introduced online curricula and resources that have helped him construct the larger context he was hoping to find. Two years ago, she encouraged William to attend a regional National Science Teachers Association (www.nsta.org) conference to learn about Journey North (www.learner.org/jnorth). He then chose to add several of the Journey North investigations to his existing unit, knowing that his students would be excited to participate with their peers across the country. Indeed, their investigations of signs of spring, including when tulips first bloom and when monarch butterflies return from Mexico, have been successful. William appreciates the way his students can generate their own questions around each of these investigations and analyze data from the Web site to pursue their answers. He notes that several students who had trouble understanding text-based information responded enthusiastically to more visual information such as data displayed with maps and graphs.

Using Internet resources, his students compare their data and observations with those from schools around the country. They noticed this year that their tulips had not yet bloomed, even though it was two weeks later than their blooming date last year. This puzzled the students until they noticed that no other school in their region had yet reported the blooming of their tulips, either. After referring to the AccuWeather database, the students noted that March was unusually cold in their region this year, and they offered this observation to account for the delayed blooming. Then they began looking at data from other regions to see if temperature data could help them predict when or where blooms would be seen next.

In the past, students' presentations were limited to their observations and data. Now students typically include data collected by others as well, and these new sources allow students to find and describe trends in the data and learn how to summarize and compare data sets. Some students have developed multimedia electronic displays that include links for downloading and adding current information. Two students who are following the path of an electronically tagged eagle update their page daily, allowing the class to make and test predictions about where the eagle will fly next based on their understanding of the bird's migration pattern.

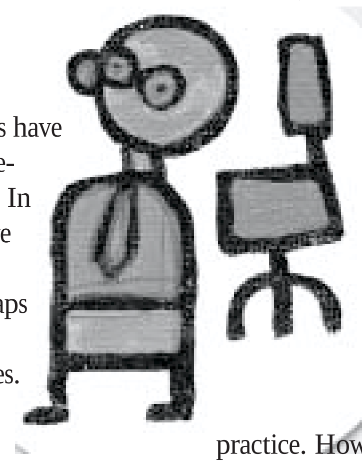
One event in particular helped William gauge the growth in his effectiveness as a teacher. Based on their finding that tulips were blooming later, the students suggest that they create a local archive to save data collected at their school for future students to study how local habitat changes over time. William is pleased that many of his students have learned to see their locally based investigations in the context of larger patterns—just the kind of growth in their understanding that he had not been able to achieve without the careful application of technology.

William is also aware of changes in the school. He notes that his colleagues' talk of "surfing the 'Net" has largely been replaced by discussions of how students use the Internet as a tool for supporting their investigations. He comments to Karen about the growing sophistication of the faculty concerning technology, teaching, and learning.

Deepening Curriculum with Technology

In this second part of the vignette, William's class is, in many ways, the same as it was. Students are actively involved in local investigations, building understanding through firsthand experience. However, as a result of William's growth as a teacher—including his work with Karen—his students' questions are broader in scope, deeper, and more reflective. This change is because of William's evolving skill in using the numerous resources available to the students, in helping them structure their investigations, and in mentoring classroom discourse.

It's important to note that the addition of the technology has not *driven* these changes in teaching and learning but rather has *supported* them. The investigation of the local ecology still grounds the students' science learning but is no longer confined to what they find at the school site. Through their use of Internet resources, students are now able to examine ecology both spatially (as they compare what lives on their school grounds with other schools') and temporally (as they compare temperature conditions from year to year). In this way, the local phenomena at Brookside are not isolated events. Rather, they are part of patterns that can be seen only by viewing the phenomena within longer time periods or as part of larger geographic areas. Students have learned to see the phenomena of spring, such as leaves budding and the lengthening of daylight hours, as part of a larger pattern of environmental change as the season progresses.



With the Internet, William and his students have access to a richer set of resources than ever before. In turn, these resources have supported the students' analysis of data using maps and other displays while also stimulating dialogues. The integration of technology into William's curriculum has helped students achieve the objectives of new state frameworks and national standards (e.g., they can make sense of data, engage in critical writing and discussion, and employ a range of reference sources).

Leading Professional Development

Looking more broadly, William's professionalism and strength as a teacher grow with his understanding of effective use of technology. Over several years, his collaboration with the school's educational technologist has led to deeper inquiries and more effective integration of technology into the fabric of the classroom.

Replacing the role of computer coordinator with an educational technologist reflects significant shifts in the school district's views of both technology and professional development. The computer coordinator kept the computers running, ran workshops for the faculty, and recommended software for purchase. In contrast, the educational technologist is an experienced classroom teacher whose primary responsibility is the faculty's professional development. In this role, she works with teachers to integrate technology into their curricula, as Karen did in helping William. Her work with William and other teachers does not begin with technology; rather, she emphasizes good instructional design—the interplay of curriculum goals, assessment, the needs of a specific group of learners, instructional strategies, and how the integration of technology can add value to the curriculum.

In the past, Brookside's students used computers mostly for games or drill and practice and occasionally as a reference source. The faculty's attendance at technology-focused workshops had little effect on classroom practice. However, when the school and district shifted to *embedded* professional development—focusing on the teachers' own curriculum through coaching, co-planning, and co-teaching—it made a deep impact. Technology has become an integral part of most classroom activities and a powerful computational tool and information resource for almost all teachers and students.

For example, Karen realized in her one-to-one work with the fourth- and fifth-grade teachers that they wanted to extend the math curriculum by linking it to investigations in their science curricula. She worked with the teachers to identify key skills, concepts, and tools that students required in their science investigations to help them select data analysis software for recording, organizing, and representing data visually and to develop a way to introduce the software that focused on students' finding meaning in the data (Grant, 2000). Some teachers implemented these new approaches with Karen, some with support from each other, and some on their own.

Support for Districts and Schools

District and school leaders find themselves challenged to move toward the vision captured by this article—a vision echoed by many experts in educational technology (CEO Forum, 1999; Milken Family Foundation, 1998).

District and school leaders looking for resources and support may want to investigate the innovative efforts in several districts and states funded by the National Science Foundation, the U.S. Department of Education, and/or local sources. Innovations have been focused on how teachers and schools view teaching, learning, and technology, and how schools and districts make decisions about technology and all the related educational issues. Specific strategies include a shift to embedded professional development, the creation of the role of the educational technologist, and the alignment of district resources.

Good descriptions of these strategies have resulted from the Hanau Model Schools Project (http://modelschools.terc.edu) and Project MEET (www.doe.mass.edu/edtech/teacher/projectmeet/default.htm), among others. For example, Wasser, McGillivray, and McNamara (1998); Brachwitz (1999); and Buffington and Monroe (2000) have described the role of educational technology and its effect on schools. Clark County School District (Nevada) has created a job description for the educational technologist (Clark County School District, n.d.) that captures the full range of the role. In addition, approaches for professional development have been developed, and research on effective implementation is being completed. For example, the Consortium on School Networking has developed a one-day introductory workshop (CoSN, 2000). Project MEET staff at TERC have developed a 14-month program for assisting teachers to develop the skills needed for this role (http://meet.terc.edu/public/TPDs/TPDs.cfm), and preliminary research on the effectiveness of this professional development program is very positive (http://meet.terc.edu/public/research/research.cfm). Effective models for the professional development of educational technologists are now available for districts to use.

Supporting Systemic Change

Karen exercised leadership in other areas, too. For instance, the school's technology committee had focused on hardware, software, and wires, so she worked with Brookside's principal to shift the committee toward educational issues. In its second year with Karen as chair, the committee initiated faculty-wide discussions that resulted in a consistent introduction and use of technology from grade to grade. Now William can count on his incoming fourth graders to know how to use a word processor and a Web browser and can expect many to solve common technology glitches as they occur. The fifth-grade teachers, in turn, have revised their curriculum to capitalize on their incoming students' skills, especially their ability to work with software that organizes and represents data. Students now expect to use and enhance the software skills they developed each year in the context of the next year's curriculum, which encourages their development of fluency with core software applications.

Changing the expectations of teachers and students required changing certain assumptions about technology: whom it was for and how it could be used. Rather than technology being employed by a few "gung-ho" teachers and students, school and district administrators now view it as integral to teaching and learning at all grades and in all subjects. The result is a much more thoroughly integrated use of technology in each classroom.

William's own development as a teacher was enhanced by the superintendent and school board placing a priority on updating the district's curriculum and student learning goals to reflect technology's new role. This change in perspective was aided by another part of Karen's work. She and her principal advocated at the district level for updated teacher evaluation and student assessment procedures that would give clear recognition to the importance of technology integration in all subjects.

These examples—updating of district curriculum, student learning goals, student assessment, and teacher evaluation procedures—highlight another important role of the educational technologist. While maintaining focus on teachers' professional development, the educational technologist recognizes the importance of advocating for *systemic* perspectives within the school and district that look at the often-complex interrelationships among the various components of schooling. The educational technologist works with all stakeholders—administration, faculty, union, parents, and community groups—to educate and to advocate for effective use of technology to support the district's and school's goals. (See Support for Districts and Schools, this page.)

Supporting Learning Communities

Embedded professional development is characterized by teachers learning new skills in the course of their daily work or in the context of their own curriculum. It often has both qualities, which were illustrated in the vignette. First, the educational technologist embedded professional development in the daily work of the Brookside teachers through coaching, co-planning, and co-teaching. Second, she taught a workshop on data analysis for the fourth- and fifth-grade teachers using their own curriculum as the content. (A description of the evolution of the role of the "building resource teacher" [Hayes, Grippe, & Hall, 1999] may be useful as a model for the embedded professional development approach of the educational technologist.)

Embedded professional development evolves as other experienced and skillful teachers begin to coach, co-plan, and co-teach with teammates and other colleagues (McNamara, Grant, & Wasser, 1998). This approach has sparked teachers to recommit themselves to their own professional development and resulted in an important shift of the school's culture: the emergence of a professional learning community of highly motivated teachers committed to linking technology to improved teaching and learning practices.

Much of the literature on school improvement points to the importance of schools becoming learning communities—places where teachers work together to develop and hone their skills and learn new approaches, rather than continue to teach in only one way (Nave, 2000). Teachers tell us that technology has created not only new ways to communicate but also new reasons for people to communicate as they collaborate in learning and integrating technology. These conversations are increasingly more focused on substantive issues of teaching and learning.

The creation of the role of educational technologist, the use of systemic perspectives, and the shift to embedded professional development are key strategies to link technology to substantive changes in teaching and learning. These strategies for change are important for districts and schools to consider as they work to get optimum value from their increasingly large investments in technology.

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