style, format, and, in some instances, topics (acceptable to the journal).

What are our focal points for future action?

Some observations:

- Few people publish.
- Most research conducted has not been published.
- Technology education as a discipline must be clearly defined, disseminated, and operationalized.
- Lack of research base in most litera ture or lack of depth on the topic(s) is evident.
- Little to no theoretical basis for our research and thus the literature that stems from the research lacks the rigor of other disciplines.
- Lack of experimental research (controlled research investigations and appropriate data analyses).
- Lack of literature on technology teacher education, mathematics/ science/ technology interface and interdisciplinary approaches, in-service programs, and certification issues.
- Little attention to diversity, minority recruiting, and retention.
- Counselors, parents, school administrators, and business/industry and their relationship to technology education have received no attention in our journals.

Some possible directions:

- Rewards and incentives for publishing.
- Increased opportunities to publish refereed articles.
- Mentorships for publishing (linking young professionals with seasoned writers).
- Promote interdisciplinary cooperation and study of technology to facilitate the acceptance of a discipline for the study of technology.
- Require doctoral research for the PhD degree to have a theoretical base and include experimental methodologies.
- Require publication from dissertations as a part of doctoral degrees.
- Expect publication as a result of grant activity.
- Provide increased funding for research activity (expanding our reach to other types of funding agencies).
- Link with colleagues outside our field to prepare and publish articles.
- Involve counselors, parents, and school administrators in our professional associations.
- Provide journal subscriptions to other professionals at our institutions.
- Encourage minorities and women to publish and provide support systems to enable this to occur.
- Seek funding for journals to support their publication costs, thus enabling refereed publications to be a reasonable length.

How can practitioners help? As technology educators, we have the opportunity to share our successful classroom experiences, results of master's and doctoral research, and perspectives on issues facing the profession. Engaging in such activity creates the environment conducive to a community of scholars. Moreover, it assists others in recognizing technology education as a discipline. It is imperative that we assist those who prepare technology education and technology-related journals in delivering publications that meet the needs of in-service and preservice teachers, teacher educators, school administrators, parents, and, ultimately, students. Beyond that, we must connect to those who are on our periphery. To achieve this end, we must all try to publish the fruits of our labor and be diligent about sharing beyond these mainstream publications.

Journal editors are eager to link less experienced writers with those who can serve as mentors. This process assists the novice in publishing and thus increases the pool of individuals contributing to the base of literature that serves the profession.

References

Brauchle, P., & Liedtke, J. (Eds.). (1997). *Preparing manuscripts for professional publication in technology education* (CTTE Monograph 15). Reston, VA: Council on Technology Teacher Education.

Zuga, K. (1994). *Implementing technology education: A review and synthesis of the research literature* (Information Series No. 356). Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education.

Dr. Liedtke is a Professor in the Department of Industrial Technology at Illinois State University, Normal. She is currently on leave directing the ISU-CIPG Center for Corporate Training and Consulting, Beijing, China. She is a member of the Gamma Theta Chapter of Epsilon Pi Tau and has received the Honorary's Laureate Citation.

3. Extending the University's Reach with Technology

by Kurt H. Becker

Using technology has always been an integral part of society. Throughout history, the available technologies of the time dictated the direction of human existence. But, technological developments have had a limited impact on education and have done little to change limited access, low quality, and low productivity and to improve the primitive technological tools used by teachers.

Our stance toward technology in education—our impressions of what it is, what it is good for, and how we should think about it—has long been a problem. Many of the failures of the past stem from this problem: The films we expected to revolutionize teaching in the 1920s, the radio broadcasts that would bring the world into every school room in the 1930s, the "new media" of the 1950s and 1960s (television, Super-8 film, language laboratories), the passion for programmed instruction of the

1960s, the novelties of distance education and dial-access audio and video in the 1970s and 1980s, and now virtual schools in the 1990s—in all these cases, we started with enormous expectations about what a particular set of technological devices, used in a particular way, might be able to accomplish. While there were a few successes (the overhead projector that rapidly spread into most of the classrooms in America, the wide-ranging dissemination of VCRs, the power of distance education and "open university" approaches to extend higher education to new audiences), there were certainly failures and criticisms such as the machines that were used once and consigned to the closet and the devices that teachers used only once a year because they were too complex. Such teacher tools had little or no effect upon the existing paradigm, and teachers could take them or leave them.

The debate over the impact that technology is having on education and what impact it will have in the future continues today. Some believe that technology is so powerful that it can effectively eliminate schools altogether. Others think that this is a basically flawed and alien ideathat is contrary to our most central notions of what a good society is.

Perhaps the primary thing to bear in mind about the interaction of technology and schooling is that the process has never resulted in anything close to what educators hoped and assumed it would do. Rather, using technology became associated with economics (employment prospects for graduates, based on the "skills needed for the information age") and with community pride ("Our school has six networked PC labs!"). In these cases, the decision makers failed to examine a central underlying assumption: We only think of education and schools as means for application of computers, software, networks, and associated technologies.

The Changes

A paradigm shift is underway. And new technological tools for learners are significantly and simultaneously moving toward the accomplishment of three major goals of education reform: better access, better quality, and better productivity (Davis, 1996).

Achieving Access

For a variety of reasons, large segments of our society have limited access to the means for learning. For many time is a factor. For others it is a matter of being out of reach of a campus.

Lack of access can also mean that a neighboring college doesn't teach what some need to learn or that the available curriculum is otherwise undesirable. Scores of students physically attending college are routinely forced to add an additional semester or school year to their college tenure simply because they couldn't enroll in the classes they needed or wanted due to scheduling, full classes, lack of course offerings, and more.

To facilitate better access there must be a change in the existing system. Converting from a bricks and mortar, labor-intensive system to one that gives learners information technology tools will require massive capital to build infrastructure, retrain personnel, and create new learning materials. Schools must yield their role as the primary providers of content and shift to a role of providing means and services for students to develop learning skills. The high speed network infrastructure that is under construction throughout the world and high speed fiber optic data lines in our homes and offices will help facilitate this access. This will facilitate an "anything, anytime, anywhere" paradigm (Wittmann, 1994), which may lead to electronic educational communities with minimum barriers of distance, time, race, age, gender, and appearance. It is likely to promote collaboration and increase the quality of education.

Increased access means learners can sign on to a course and begin taking it the minute they realize they need it. It means they can pursue aspects of a subject that are relevant to their immediate need and demonstrate mastery by applying what was learned in a meaningful context. It means learners progress through the components of a course at an individual pace rather than in lockstep fashion. This will result in a changing relationship between school and industry since industry demands the use and knowledge of current technologies. As technology becomes more commonplace, it will be used in all sectors of life, and this will directly alter students' learning needs and abilities.

A curriculum addressing this need may cost millions to produce, but once completed, the costs to manufacture, distribute, and update it are moderate. Such a curriculum could stand alone or be used in conjunction with commentary and individualized lesson plans from an online mentor. The curriculum could be partially or entirely completed at home or at work, and at a pace that suits each individual learner.

Access to education primarily means giving up the notion that a classroom is a place of assembly at a single place and time. It also means and requires the revolutionary step of putting learners in charge of their learning process. The conventional classroom lecture takes place in a cloistered set of buildings with rows of students facing the teacher, who has prepared the lesson he or she thinks is important. It creates an environment that tends to ignore higher order learning skills such as creativity, independent thought, inquiry, research, leadership, and innovation. Many experts will agree that the classroom is one of the few places of human activity that someone who had slept for 200 years could wake up and return and still feel comfortable.

Conversely, the learner who is his or her own teacher has far greater access to learning through the convergence of computers, telecommunications, and traditional classroom media. This, in turn, can increase quality and productivity.

Achieving Quality

Looking at today's education, change is inevitable. Technological changes will have an effect on the entire teaching system. Technology is providing new tools of thought and action that graduates *must* be able to use in order to compete on a global basis.

A better, more affordable, more widely used information technology system must continue to be developed. The library is one place to proceed with these changes. Change will bring the advent of the digital library, which in turn will create regional and national libraries. This information will be available to learners on-line, minimizing search times. These libraries will also deliver multimedia and electronic (digital) textbooks, which will give learners text, pictures, video, and sound. All of

this can take place in less space because of digital technology. Libraries will be easily accessable and open themselves to interaction with the learner.

Currently, multimedia technologies are emerging that provide new ways for education to do business. They enable education decision makers to make dramatic changes in delivery, evaluation, and so forth.

What are the emerging components of multimedia?

1. Library services available over campus networks.
2. Conceptual designs for electronic libraries.
3. Development of permanent and portable multimedia delivery systems.
4. Effective use of all of the components of a digitized communications network (voice, video, and data).

Multischool classrooms on the Internet will soon begin to proliferate. Increasingly, sophisticated "search engines" make it easy for even an eight-year-old to become a sophisticated researcher and explorer, locating new information databases and exploring new curiosities on a daily basis. Providing a more learner-centered system will not change everything.

Some students will continue to want physical proximity to other students and teachers. Other learners will want only occasional support and guidance, and some will seek independent study and courses of quality. Many students will want customized learning programs comprised of individual courses, course components (modules), and short-term certificates. Today's learner is a lifelong learner. As colleges learn to exploit this opportunity, they will custom build and import the "courseware" to meet the individual needs of learners who enroll.

The use of telecommunication tools introduces new platforms for knowledge. Students can collect, manipulate, organize, analyze, evaluate, and reflect alone or in groups with divergent sources of knowledge and information worldwide. If a student wants to know what a "Communist" is, he or she can correspond with a teacher, student, or government minister in Cuba or China—a real flesh-and-blood Communist (Kerr, 1990a).

Telecommunication creates whole new audiences for the student. He or she must learn to analyze each audience and learn to communicate in a context-specific, coherent way. There will have to be changes in the way information is distributed and shared, and new strategies for storage are needed (Tennant, 1995). The use of technology to help learners access, search, and retrieve information is increasing at unprecedented rates. A major part of establishing learner access is the recognition that a teacher comes in many forms and through many pathways, some not yet invented.

Achieving Productivity

Information technology has generated dramatic cost-benefit gains in virtually every other sector of our economy: financial services, manufacturing, retail distribution, health care, entertainment, and government. Why, then, is our most vital segment, education, lagging so far behind?

There has been no incentive to change the local elementary school, and the community college has no real competition. Tenured faculty have little motivation to change their teaching methods as long as their classes are full and there is a demand for services. Many teachers are themselves resistant to technology and, consciously or unconsciously, terrified that it will displace them.

Administrators of traditional schools are beginning to realize that they will not have a captive market much longer. Technology-based companies, leveraged by inexpensive manufacturing and cheap distribution (e.g., the Internet) will increasingly turn out attractive and relatively inexpensive new ways to learn. New communities of learning are being created daily on the Web.

While encouraging innovation within the faculty, universities are highly resistant to change institutionally (Hawkins, 1992). What makes the transition inevitable is that educational productivity will continue to decline under the present system; costs continue to rise and access is increasingly denied. As educators, our choice will be to consciously move with change or be dragged along by it. Unless educators learn to work with the private sector to use technology, they may begin to disappear.

As we shift control and initiative from teacher to learner, the role of faculty member shifts to the facilitation of increasingly autonomous student practices. Curriculum design becomes the art of posing problems, introducing large questions and then facilitating work on them. The teacher shifts from lecturing to fomenting questions, doubts, and uncertainties; suggesting strategies of inquiry; and questioning the quality of reports and conclusions. This kind of work will require great sensitivity and dedication to individual learners (Kerr, 1990b).

There will also be teachers who lack heartbeats. There will be a variety of computer-generated video-sound-and-text-based experiences. Exciting new technologies such as virtual reality and multiuser simulated environments will challenge users to use abstract reasoning to navigate knowledge-intense environments and simulate physical tasks. Using this kind of technology, students can encounter real geography, history, science, language, or business problems by themselves or with other students scattered in space and time.

Serving as a successful mentor will require new teaching techniques in design, facilitation, and counseling. Students may be involved in facilitating learning experiences, such as the creation of an on-line conferencing process where students simulate a joint research term in a fictitious company. Students might publish their research findings in an on-line journal, offer critiques and questions about each other's findings, and be challenged by the faculty facilitator who plays the role of the business interest that commissioned the research.

The real value of any good technology is not that it will do things for us faster, better, and cheaper, but that it will make us better at what we do. Learning is innately and uniquely human. Digital tools will provide new levels of access, analysis, simulation, and synthesis that will generate increased learner participation in intellectual work. With these new capabilities, learners will not need teachers to teach them but rather to facilitate their learning skills, the development of their character, and their vision of the future. This will assist in achieving the educational goal of better access, better quality, and better productivity. However, there will be numerous issues with

which those in education will be faced with since change does not occur without difficulties or challenges.

Some Issues Related to Change

1. As information technologies become digitally based, distinctions between voice, video, and data will blur, causing attention shifts to an information infrastructure. This will amplify the speed and accuracy with which information will be available to education and industry. The information technology industry will continue to adjust to the changes in education. These changes will be determined by economic factors, which include the dropping cost of technology hardware and developing multimedia for the home consumer market. These changes will increase market size, which in turn will decrease the ability for education to have partnerships with industry because the reduced prices of hardware will make it difficult to develop a win-win situation.

2. Higher education will become less important to vendors as the market expands into the home. Vendors will support the creation of high-end software that, in turn, will drive and stimulate sales of hardware and operating systems to support the software. Vendors will have a vested interest in developing multimedia applications that require more powerful, faster technology. This could result in education changing dramatically in the method of delivery to maintain its competitive market share of the existing student populations.

3. Digital technology will alter the lecture paradigm when we harness the energy of the networked virtual university and engage in collaborative instruction. Collaboration will involve more than one individual involved in course design and delivery, and students who actively participate in instruction. This will engage students and the school systems in active, meaningful competition for the digital age.

4. When designing an educational system, we can certainly predict how changing the process will send a more desirable message to learners. What we can't predict are the elements of design and delivery that rely on human character and individual motivation, and this human element remains crucial. Again, we should consider whether a well-rounded education is a function of teaching or of a learner making selections from a balanced curriculum.

Because of the capacity afforded by information technology to make learning more outcome oriented, opportunities for accelerated learning will multiply. As a new generation of learners becomes accustomed to deciding when to learn, what to learn, how to learn, and even how progress is to be certified, the need for human intervention in the process of learning will diminish to infrequent high-quality counseling and mentoring sessions. The inherent "learning machine" can be liberated.

References

Davis, E. (1996). *The future of education.* Available: http://www.wco.com/ ~mktentry/edfutur.html

Hawkins, B. (1992). Symposium panel discussion at the annual meeting of the Association of Instructional Technology in San Diego, CA.

Kerr, S. T. (1990a). *Alternative technologies as textbooks and the social imperatives of educational change*. Chicago: University of Chicago Press.

Kerr, S. T. (1990b). Technology: Education: Justice: Care. *Educational Technology, 30*(11), 7–12.

Tennant, R. (1995). Multimedia. *Syllabus, 9*(5), 30–36.

Wittmann, A. (1994). Infrastructure. *Network Computing, 5*(13), 28–30.

Dr. Becker is an Associate Professor in the Department of Industrial Technology and Education at Utah State University, Logan.

4. Creative Problem Solving: A Unique Aspect of Technology

by Andrew E. Schultz

Education is teaching people how to think. Training is teaching people how to behave within narrow specializations. We do both in our schools. This is as true of technology studies as it is in any other part of the school curriculum.

Our school system is charged with the responsibility for the development of cognitive skills in students. Basically, this means that students must be taught to use their most extraordinary feature, the brain, to ensure our survival and to improve our lives. We humans have been blessed with at least four cognitive gifts that have enabled us to conquer nature and recast our world. Only three of these gifts are evident in the core curriculum: (a) the ability to make sounds and symbols that convey meaning (or communications), (b) the penchant for quantification (or mathematics), and (c) the ability to observe objectively and make rational decisions about these observations (or science). The fourth gift, tool use, is the ability to make, modify, and wield tools in a productive fashion for the improvement of society. This fourth gift is not part of the core curriculum, but it should be. Without development of the fourth gift, skills in math, science, and language are just empty tricks, mere glib-tongued, sharp-brained sophistry. Ancient Greece and China, the pre-Columbian Incan, Mayan, and Aztec societies of South America, and the dark-age and medieval Europe are examples of some of the societies that failed to make full use of all four gifts to their ultimate detri-