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 detriment. That tool use is not a recognized integral partner in the core curriculum in America is as short sighted as the trivium was in the Middle Ages.

In secondary education today, teaching tool and equipment use is the province of technology education and, as such, it is where the melding of the core curriculum takes place. It is the ideal site for contextual learning to happen, and increasingly, our best teachers are realizing this. They are making the association that applied learning enriches the core curriculum by enabling students to stretch cognitive skills and actually synthesize new knowledge. It is also where real problem solving is taught and occurs.

But what makes technology education really unique is that both kinds of problem solving are taught. *Both kinds?* Yes, few people realize that there are actually two sorts of problem solving. Applying algorithms (or the application of known solutions to classes of existing, already solved problems) is commonly taught in our schools. Outside of an art class or a traditional shop program, however, creative problem solving (or how to solve unique or unsolvable problems) is rarely addressed. While capabilities in this second type of problem solving are never given curricular space to develop, these are the very abilities that may prove critical to our survival as a society and even as a species.

Applying algorithms has proven a rich source of techniques for the exploitation of the world's resources—our dominance of the world owes much to this way of thinking. At the same time, however, despite the impressive technological advances of the late 20th century, our collective capacities to deal with the global moral, economic, social, and environmental consequences of these advances are already bankrupt. These challenges are just the bills coming due today. The difficulties of the next century seem to expand exponentially with every scientific, technologic, and economic innovation, even as we fail to solve those problems facing us today. Ironically, these problems result from the very mastery of this vastly fruitful first kind of problem solving, applied algorithms. It is unlikely that the solutions to these kinds of endemic problems can come from the same technique of thinking that produced the problems in the first place. Rather, the solutions we desperately need are the kind of paradigm shifts that spring from the second kind of problem solving, creative problem solving.

Unfortunately, there is a large body of evidence which supports the beliefs that expertise in applying algorithms is developed at the expense of creativity and that as one masters a body of knowledge and its traditional organization, it is exceedingly difficult to slip outside of that organization and see it again in a new, reordered, and more meaningful manner. Rare are people such as Copernicus and Galileo, who were experts and yet able to recast their knowledge in a new, more meaningful fashion. More often, when one is schooled in a specialty and in how to organize and process information about that specialty, there's an almost inescapable tendency for one to see the rest of the world through that same prism of narrow expertise as well. In educational psychology terms, this is called functional fixity (Moates & Schumaker, 1980).

To illustrate functional fixity, consider the following story that the great Gestalt psychologist, Wolfgang Kohler, once wrote of his favorite chimpanzee, Atlas, and the puzzle he had posed to him. Kohler was studying primate problem solving at the time and had done this experiment several times prior to working with Atlas. He would suspend a basket of fruit from the top of a fairly spacious cage that also held an ape, several sturdy boxes, and a long stick. Most apes would try the stick first, but finding it too short, would puzzle for a while and then in a flash of what Kohler saw as "insight" use a box to stand on to get the fruit. Atlas, however, could not solve the problem. Kohler sat outside the cage taking notes while Atlas studied the fruit and the boxes. One hour passed. Two. Kohler grew increasingly worried about Atlas. He was the oldest ape, and he grew increasingly despondent, looking frequently at Kohler with pleading eyes. Finally, Kohler could stand it no more, and he entered the cage to reassure Atlas. Immediately on entering the cage, Atlas took Kohler by the hand, led him so that he was directly under the bunch of fruit, and then climbed Kohler until he could reach it. Kohler took this as an example of both his own and Atlas's inability to recast old familiar forms into new innovations or functional fixity (Moates & Schumaker, 1980).

These different types of problem solving are liked and relied on by different kinds of students, too. While business and industry report that they want people who are critical thinkers, team players, and problem solvers (Rogers, 1995), they are not thinking of the creative problem solvers. Business and industry want those with a knack for applying the heuristics and algorithms of life to slightly new situations. They want people who modify, not those radical random abstract folks with their penchant for unconventional creative behaviors. These creative problem solvers are barely acceptable in polite society. They have a knack for abandoning conventional solutions and finding really unique (and sometimes unsavory) ones. They are hardly team players and not readily acceptable by or as critical thinkers. And yet these creative problem solvers break the code and decipher the secrets of the universe. Of course, we have learners with both sorts of thinking preferences in our technology classes. Schultz (1985), for example, found that while 54% of 217 students in secondary industrial education programs scored as abstract sequential or concrete sequential learners (those people who prefer to learn applied algorithms), 20% scored as random abstract learners. In other words, in this sample almost one fifth of industrial education students preferred to learn to solve problems in a creative rather than lockstep fashion.

All people share creative and critical thinking attributes, but the individual usually prefers one mode of thinking over the other. Carl Jung (1976) compared this phenomena of the interaction between dominant and auxiliary psychological functions to handedness. Most people demonstrate a preference for using the right or left hand fairly early in life and that preferred hand becomes quite skillful; the opposite hand however remains relatively unskilled—just try writing your name with your dominant and auxiliary hand and it will be apparent which is skilled and which has remained undeveloped and childlike in its capabilities. And even though we right-handers learn to catch fly balls with a mitt on our left hand and master shooting layups from the left side of the basket, these skills are almost always less well developed than those of the right.

Over the last 20 years, we have moved away from traditional industrial education and strongly towards more rigorous forms of technology studies. We have sought to develop methods and programs that foster a higher order of thinking skills. Let us not do so at the expense of our ability to slip outside of conventional thinking and dream up really new paradigms. Think of Steve Jobs and Steve Wosniak at work in their garage, rethinking the ways that people and computers interact. Think of Einstein and his inability to master the algorithms of simple mathematics, yet able to rethink the universe. Remember Piaget's words, "The final form of learning is play." In our efforts to provide workers for industry and citizens for our society, the balance between training and education and between applying heuristics and solving problems with creativity is always a precarious one. In our secondary technology programs, we must take care that we do not lean more toward training than education.

References

Jung, C. (1976). *Psychological types*. Princeton, NJ: Princeton University Press.

Moates, D., & Shumaker, G. (1980). *An introduction to cognitive psychology*. Belmont, CA: Wadsworth.

Rogers, G. E. (1995). Technology education curricular content: A trade and industry education perspective. *Journal of Industrial Technology Education, 32*(3), 6–21.

Schultz, A. E. (1985). *The preference for intuition or sensation in 217 secondary industrial education students in Nebraska*. Unpublished doctoral dissertation, University of Nebraska-Lincoln.

Dr. Schultz is an Assistant Professor in the Department of Vocational and Adult Education at the University of Nebraska-Lincoln.

5. Technology: The Heartbeat of Education

by William D. Paige

What does the term *technology* mean? What does the term *engineering* mean? Are they one in the same? One collegiate dictionary defines technology as "...a scientific method of achieving a practical purpose; or the totality of the means employed to provide objects necessary for human sustenance and comfort" (Mish, 1988, p. 1211). Wright and Lauda (1993) defined technology as "...a body of knowledge and action, used by people, to apply resources in designing, producing, and using products, structures and systems to extend the human potential for controlling and modifying the natural and human-made (modified) environment" (p. 3). According to Savage (1991), technology is a body of knowledge and the application of resources using a systematic approach to produce outcomes in response to human needs and wants. Technology is "...the application of knowledge, tools and skills to solve problems and extend human capabilities" (Smith, 1994, p. 2). The common thread that runs through all of these definitions is that technology is about doing to extend human capability.

Engineering is defined as "the application of science and mathematics by which the properties of matter and the sources of energy in nature are made useful to people in structures, machines, products, systems, and processes" (Mish, 1988, p. 412). The Accreditation Board for Engineering Technology (ABET, 1997) defines engineering as "...the profession in which knowledge of the mathematical and natural sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind" (cover). Both engineering definitions emphasize utilizing a combination of mathematics and scientific theories with materials and nature to satisfy the needs of humankind.

From these definitions, it is easy to see that engineering and technology are not the same. The field of technology is much broader in scope than engineering. When comparing technology and engineering, Dugger (1994) found several areas of similarity as well as several distinct differences. Both engineering and technology are concerned with "how to" and "the solution of problems" (p. 8), and both are driven by "social acceptance and success at the marketplace" (p. 8). Both are based on the study of the principles of science, mathematics, processes, and systems. However, a fundamental difference does exist between technology and engineering. Technology places a greater emphasis on the application of these principles to solve problems and produce products while the focus of engineering is towards research, design, and developing new products and systems. The study of technology is directed from something concrete to the abstract while engineering is directed by theory and ends in specific recommendations or solutions. However, a certain level of interdependence does exist between engineering and technology as well. Engineering and technology are both dependent, to some extent, on one another. True progress is not possible without both.

Bensen and Bensen (1993) proposed integrating technology and engineering experiences into the school curriculum. They asserted that engineering and technology content organizers are built around (a) disciplines, (b) systems, (c) processes, and (d) impacts. Furthermore, they stated that "it is readily apparent that most contemporary and relevant technology education programs already