

The Journal of Technology Studies

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Editor Gives Journal a Boost and Leaves Prematurely

Jerry Streichler, Editor

Cece Iandoli made significant contributions during her brief term as this journal's Editor. To the Epsilon Pi Tau Board of Directors' charge to prepare this publication for entry into the 21st century she responded by engineering a well-received change in the journal's outward appearance and internal design and layout. The Board of Directors also sought a journal that, while maintaining its prominence as a scholarly publication, would better serve its Epsilon Pi Tau members and subscriber readers who were increasing in number and who represented more diverse technology interests, cultures, and nationalities. In response, Cece devised guidelines and took initial steps to extend the journal's subject matter and range of topics.

We were delighted for her when she was promoted to full professor and then appointed to chair her department at San Francisco State University. That emotion changed to disappointment when we (and Cece) realized that the demands of those new responsibilities were seriously affecting her ability to fulfill editorial responsibilities. If only she would have been able to continue with the program that we had envisioned. Nevertheless, we were fortunate to benefit from her creative energy and enthusiasm and the paths she blazed during her almost two years of service to Epsilon Pi Tau.

This writer appreciated and valued the Iandoli presence: first, as a mentor in transferring the Editor's reins to her, and then, after she took full responsibility, as an observer and supporter of her ideas and helping with their implementation. With her departure and a return as a "new" Editor it makes sense to promptly implement an innovative approach to publishing *The Journal of Technology Studies* that we had been planning for Cece to manage. The concept places the journal at one of three interrelated elements of what we call the Epsilon Pi Tau Publication and Information System. They are:

1. *The Journal of Technology Studies*. A publication and dissemination change marks the 2001 volume. We have already received positive feedback about the concept of posting individual articles

online as they are completed. We hope that the inaugural hard copy of the 2001 volume that readers will receive early in 2002 will be equally well received as a useful alternative to the material that has been posted on the World Wide Web during 2001.

2. The Epsilon Pi Tau *Preceptor* (the official Newsmagazine). The first copy of this second element of the information and publication system was mailed to members last fall. We have received positive feedback on it. From its attractive design, layout, and typography it is clear that the Epsilon Pi Tau *Preceptor* is different from its predecessor, the long-serving "Quote-Unquote" Newsletter. Our dream is to make it a truly general magazine that includes information relating to leadership, technology developments and issues, career development, chapter programs and accomplishments, events and highlights from regions, and achievements of individual members. These, in addition to announcements of honors and awards and business matters of the organization, will make up this new periodical.
3. The Epsilon Pi Tau Web Site. The existing Web site will be significantly upgraded in design and comprehensiveness. It will have a new address, and because of its linkage and other capabilities this comprehensive, user-friendly, interactive Web site will be the heart of the Epsilon Pi Tau Information and Publications System.

The Web site will include sections of general information about Epsilon Pi Tau. These will be open to members and nonmembers to provide them with critically important information about the organization and about technology. But only active Epsilon Pi Tau members will be able to access other secure pages. These will contain Epsilon Pi Tau publications online, and career and advancement information as well as information on technology and technical issues and events.

As a one-stop service, members will be able to link with a variety of other professional organizations and professional and scholarly journals and magazines related to the many disciplines and specializations in the technology professions served by Epsilon Pi Tau.

Secure chat rooms, also only accessible to Epsilon Pi Tau members, will facilitate communication with other members throughout the world. Such an exchange and sharing of professional information relevant to common career and technical interests will certainly be beneficial to members.

Business matters, including payment of dues and ordering of such items as Epsilon Pi Tau jewelry, will be enabled with security. And finally, members will be able to communicate directly with Trustees, Regional Directors, and the executive staff at the International Office.

So, how does all this relate to you, our members and readers? The short answer stems from the Board of Directors' wish to build on the journal's reputation and to improve and enrich member services. As an example, we share a not widely known fact that the journal

maintains the most extensive article solicitation system of any comparable journal that serves our fields of technology. This has been done to ensure that our members will enjoy the benefits of the best and most diverse scholarly materials that could be acquired. The system described in the preceding paragraphs expands on the notion of providing the best that is possible to members. The three elements not only provide publications with enlarged scope, but open significant and meaningful communications devices. These will provide member enrichment opportunities that we hope will serve and, indeed, help members as they progress and advance in their careers in a technology profession and even hold their interest in retirement.

Naturally, Cece cannot, nor would she, claim credit for all that is reported here. What she did with the journal has served the best interests of the Epsilon Pi Tau membership. The remaining elements of our publication and information system will do no less. Thanks, Cece! **JS**



Technology Curriculum Organizers That Could Make a Difference

Ernest N. Savage

As we look to the future of our profession, it will be important to consider content that will be reflective of technology while being relevant to those whom we wish to serve. Of course, attempting to even be remotely accurate more than three years ahead of an exponential curve is, at best, a guessing game. However, that shouldn't prevent us from using the most contemporary resources to support our thinking.

I hope, therefore, that as the descriptive concepts of the technological studies discipline for the future are explored, it will be not just be done in an oblique way but, more importantly, be provocative and future oriented. One should not just build on the traditions of our field of study; rather, we should attempt to be paradigm pioneers and "look to the fringes" of our profession.

It is in the nature of exponential growth that events develop extremely slowly for extremely long periods of time, but as one glides through the knee of the curve, events erupt at an increasingly furious pace. And that is what we will experience as we enter the 21st century (Kurzweil, 1999).

If we examine the organizers typically proposed for the study of technology (design, interchangeability, innovation, and the like), we can safely say that these are the same organizers the world has known and used over time in terms of technology, and I do not know why we would not continue to use these. We will continue to use them, along with the content organizers in the bio-related, physical, and informational technologies because they constitute a good part of our tradition.

However, it is much more challenging to focus on some concepts that have always been on the fringe of our discipline and charge ourselves to think about what we could and, possibly, should introduce into the core of our technology studies curricula. Perhaps we need to pay attention to that which makes us human and not lose sight of "humanness," or as Naisbitt (1999a) would put it, keeping the balance between high tech and high touch. High tech/high touch means embracing technology that preserves our humanness and rejecting technology that intrudes upon it. It

is recognizing that technology is an integral part of the evolution of culture, the creative product of our imaginations, dreams, and aspirations—and that the desire to create new technologies is fundamentally instinctive. But it also recognizes that art, story, play, religion, nature, and time are equal partners in the evolution of technology because they nourish the soul and fulfill its yearnings. It is expressing what it means to be human and employing technology fruitfully in that expression. It's appreciating life and accepting death. It is knowing when we should push back on technology, in our work and our lives, to affirm our humanity.

This article is not just about the "softness of technology." However, this aspect must be considered and reflected upon if we are to see our future through as clear a lens as possible. Along with reflection, a number of questions must be asked: How does technology affect our lives today? What role does technology play in our work and play? Did technology live up to its implied societal benefits of simplifying our lives and giving us more leisure time to relax and enjoy our lives?

And what about the future? Here are some other questions we need to start thinking about: How will technology affect our lives tomorrow? Will technology determine who we are, what we do, how we think? Will we engineer our children the same way we engineer products? Will those who are wealthy have the opportunity to create a master race of designer children?

Identifying the Organizers:
Proposing a New Way of Thinking
About Technology

Some of the organizers that deserve consideration as units within the new technology studies framework are evolution, communication, spirituality, intelligence, consumerism, and life cycles. Although all of these organizers deserve consideration, only the last two are discussed in depth.

Evolution

Evolution was the original creator of intelligence, and technology was the one

human variant of evolution. Where we will evolve given the exponential growth of technology is worthy of focused study. Technology goes beyond the use of tools—it involves a record of tool making. And a key requirement for an evolutionary process is a “written” record of achievement (Kurzweil, 1999).

Communication

The process of providing a record will always be an essential component of progress. The genetic code of early life forms was their chemical composition (of the organisms themselves), and so it was in the case of early tools; the tools themselves were the records. Then came written language and now databases. Ultimately the technology of communication itself has created new technology. In many ways it appears that we’ve gone “full cycle” with gene identification, using the genetic code to influence much of our physiology. In the first quarter of this century we can expect continued exponential growth in this venue to include 3-D holography and access to virtual environments as an individual or with others through a remote portal.

Spirituality

Our emerging understanding of genetics is beginning to upset our spiritual and political leaders in much the same way as Galileo did in the early 1600s, when he argued that the earth revolved around the sun, and as Darwin did 150 years ago, when he challenged the theory of creation. Our sense of space and place in the universe has changed as has our understanding of our place in nature. The mapping and sequencing of DNA and the technologies that this knowledge spawns will permanently alter our understanding of humans. We have experienced tremendous macro to micro paradigm shifts from the universe to nature to the human being, and each has had profound implications for organized religion and for our sense of personal spirituality (Naisbitt, 1999d).

The merging of medical technology and science, particularly manifested in genetic engineering, has continued to provide fodder for the platforms of those representing religious faiths. The work of projects such as “The Human Genome” has forced moralists and ethicists to examine the philosophical underpinnings of what it means to be human.

Theories of genetic determinism—that our genes determine not only our physical makeup but also our sexual preferences, our levels of aggression, and possibly even our propensity to be religious—are causing theologians to examine their ideas of free will, the human need for religion, and the very existence of God (Naisbitt, 1999d).

“Frankly, if it turns out that genes control 100 percent, I think religion is in trouble,” said orthodox Rabbi Irving Greenberg, president of the Jewish Life Network in New York City. “I think the whole world’s in trouble because ultimately religion is predicated on the belief of free will” (Naisbitt, 1999d).

Intelligence

The difficulty in many applied higher education programs lies in their ability to provide their clients with adequately applied problem-solving skills (Kahn, 1998) rather than mechanical knowledge of software. Too often learning is about bringing students in contact with the most recent technology rather than providing opportunities for them to engage their cognitive-expanding and creative-generating skills. It is the instructor’s responsibility to balance the seductive aspects of new technology by predicting that their present technical knowledge will become obsolete while their learned knowledge from creative problem solving will not. As processes become increasingly automated, critical thinking skills will become the industrial standard essential for job profiling. Innovation, talent, and creativity should not be annulled by the pragmatism of technology (Faiola, 1999).

Consumerism

Although consumerism, like communication, has a rich history, it is an exploding field. The two biggest markets in the \$8-trillion-a-year economy of the United States are (a) consumer technology and (b) the escape from consumer technology (Naisbitt, 1999b). As such, consumerism requires a close look from technology educators.

According to Naisbitt (1999c), all technologies tend towards consumer technologies, and these gadgets, gizmos, and have-to-have upgrades are powerfully changing our relationships with time. We all try means of escape from the pressures of our work-a-day world. The old rules of having disposable

income before spending it on frills have long passed to the point that a \$500 concert night is not out of the question for an individual without full-time employment. On the more traditional side, we now have bigger and more technological recreation vehicles and faster and more realistic video products. The result is that consumer technologies influence and shape our lives until we finally accept them as the norm. The babysitter of the 1960s—the television—is quickly being surpassed by video games that are, for all practical purposes, unregulated. As such, these video portals allow children to access a world that blends the borders between reality and imaginary. While adults may look at these games as toys and entertainment, children may not be able to distinguish between fantasy and reality. Violence in our children's media may have a direct correlation to violence in our society. Consumer technology is changing the way we understand time—collapsing, crunching, compressing it. Today technology is a self-perpetuating engine run by upgrades, add-ons, and refills. It accelerates our lives and fosters dependence, which necessitates relief, for which we all too often turn back to technology for the most accessible, immediate solution. Stressed out? Buy a massager. Life's disorganized? Buy a personal electronic organizer. Traveling with children? Buy a Gameboy. Neighborhood unsafe? Buy a security system.

If we were able to paint a scenario of a family at the end of the workday, it might give us a glimpse of the effect of consumerism on our lives today. Consumerism has gotten us to a point where the following scenario might be considered common practice.

Your PowerBook sits on your desk at home beside a stack of important unread articles, but you choose a cold beer and a little TV to unwind. The evening passes quickly, and you retire to bed after the nightly news and an earful of office voice-mail. You lie awake while your spouse talks on an Internet chat room, and inventory the events of your day. You feel ashamed about losing your temper with a new co-worker; you realize that the repairman didn't return your call as promised even when you beeped him; you wish you had read your son a bedtime story despite being tired; you feel proud of holding the real estate deal to a 4 percent commission. Your mind skips ahead as you fall asleep while making a mental checklist of things that need to get done tomorrow. You wake at 6:30 A.M. with no memory of dreaming. You rise immediately to a pot of hot coffee and e-mail. You then head to the car with a bagel in your hand for a twenty-minute commute during which you listen to the first installment of a popular

business book because you're falling behind in your professional reading. The cell phone rings, and your colleague reminds you a client is due for a meeting in fifteen minutes. Your thoughts drift past the noisy narrator to an overwhelming desire to get out of town. (Naisbitt, 1999b, p. 1)

As sad as it is to envision this kind of "techno-world," the picture is more psychedelic for the privileged youth of this environment—those who have access. As is often the case in our technologically enhanced world, we have less time for the "old-fashioned important things" such as determining the social responsiveness of our children's activities. The real-life example of this came screaming across our media a few years ago with the advent of Columbine. Like Kent State, we will never be able to separate the place from the act of violence. "Doom will become reality!" wrote one of the two Littleton terrorists before the Columbine High School killings began. Those two student killers won a place in history (for the moment) on April 20, 1999, by committing the worst school massacre in American history. They killed 12 fellow classmates, one teacher, themselves, and wounded 23 others in a five-hour siege. "What they did wasn't about anger or hate," said their friend Brooks Brown. "It was about them living in the moment, like they were inside a video game."

The two teenage boys were immersed in America's culture of violence delivered through television, films, the Internet, stereo systems, and electronic games such as Doom, which they played for hours daily, including a personalized version of the game that one of the boys had modified to match the corridors of his high school, Columbine. "You're one of earth's crack soldiers, hard-bitten, tough, and heavily armed," describes the instruction manual of Doom, which has sold about 2.7 million copies. "When the alien invasion struck Mars, you were the first on the scene. By killing, killing, and killing, you've won." The boys had linked their home computers so they could play first-person-shooter "death matches" against each other while sitting alone in their own rooms.

America is entrenched in a culture of violence. Our reputation in the world as a violent culture is based on crime statistics, but far more prevalent—and damaging—is the steady stream of violence on our screens: film, television, Internet, and electronic games. And many electronic games, which grant the player the privilege of pulling the trigger, are relentlessly violent, militaristic, and graphic. Living in a

Technologically Intoxicated Zone, we are not troubled by the violence on our screens, yet we are perplexed by the violence committed by our young. (Naisbitt, 1999c, p. 1)

Life Cycles

Perhaps the attribute of technology that is most likely to be added to our curriculum is one that is less controversial but reflects a new and updated approach to viewing our products of technology. To quote Einstein, *we don't need to think more, we need to think differently*. Though not actually new, it is a process that is not often addressed in our general study of technology—the process of life cycles.

The importance of this process may become clearer when the following observations are made:

- We are in a constantly tightening time frame market.
- Product life cycles are shorter, making it more difficult to achieve long-term goals.
- Competition catches up to innovation very quickly.

Observations such as these support the need for the use and thorough understanding of life cycles. Technology studies lends itself to the understanding of life cycles as presented in Kurzweil's (1999) model of the life cycle of a technology in *The Age of Spiritual Machines*. Kurzweil believed that technologies undergo their own characteristic life cycle, of which there are seven distinct stages. First is the *precursor* stage, where dreamers contemplate the prerequisite elements of a technology coming together. Dreaming should not be confused with inventing, by the way, even if one were to write down the dreams. For example, da Vinci drew convincing pictures of airplanes and automobiles, but he is not considered to have invented either.

The next stage in the life cycle of a technology is indeed *invention*. This is a brief stage. (To use an analogy, this is not dissimilar to birth after an extended period of labor.) The inventor blends curiosity, scientific skills, determination, and usually some bit of showmanship to combine methods in a new way to bring a new technology to life. Edison was a master at this stage.

The next stage is *development*, during which the invention is protected and supported by dotting guardians (which may include the original inventor). Usually this stage is more crucial than the invention and may involve

additional creation that could lead to even greater significance than the original invention. For example, many tinkerers had constructed finely tuned horseless carriages, but it was Henry Ford's innovations with mass production that enabled the automobile to take root and flourish.

The fourth stage is *maturity*. Even though it continues to evolve, the technology now has a life of its own. It has a place in part of the community, so interwoven in the fabric of life that many observers think it will last forever. Imagine the horse collar prior to the Civil War. This circumstance presents an interesting drama for the next stage, *pretenders*

During the pretenders stage, an upstart threatens to eclipse the older technology and its enthusiasts prematurely predict victory. The pretenders may even have some distinct benefits, but they are missing some key element of functionality or quality. When in the end it proves to dislodge the established technology order, the technology conservatives take this as evidence that the original approach will indeed last forever. But this victory is usually short lived. Shortly thereafter, another new technology typically does succeed in pushing the original technology into *obsolescence*.

As obsolescence approaches, the original technology lives out its senior years in gradual decline. New competitors are beginning to take over. This stage (perhaps 5-10% of the life cycle, according to Kurzweil, 1999) finally yields to *antiquity*. Examples of this are the horse and buggy, harpsichord, manual typewriter, and most applications of the electromechanical typewriter (Kurzweil, 1999).

An example of the entire seven-stage life cycle model is the phonograph record. In the mid 19th century, there were several precursors, such as Edouard-Leon Scott de Martinville's phonautograph, a device that recorded sound vibrations as a printed pattern. Thomas Edison in 1877 brought together his scientific skills and techniques to invent a device to both record and reproduce sound. Many of us can still recall the refinements that resulted in the 45 and 33 rpm "platters" that were introduced at the end of WWII, making this device a mature product of technology.

The pretenders were many, but most memorably were the 8-track tape and the cassette tape—a significant innovation because the latter could be recorded by the consumer. However, the tapes were still quite noisy and

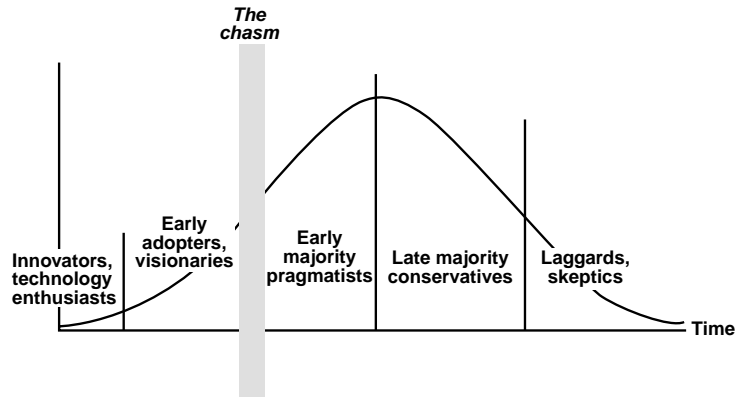


Figure 1. Life cycle of an innovation.

they were difficult to randomly access. They also were prone to wear more quickly than a well-maintained record. And, how can any of us who have experienced tape running out of the cassette forget that fatal flaw! The real push toward obsolescence was given by the digital compact disk, which offered all of the positive characteristics of the best of the record and tape technologies while providing virtually distortion free sound. While records and albums are still produced for the vinyl audiophile, it will become a smaller and smaller market while the CD and its pretenders lead the way to the next level.

Life Cycle of Innovation

The classic study of the diffusion of innovation exemplified by the transition from early to late adopters can be found in the work of Rogers (1995). His fourth edition of *Diffusion of Innovation* classifies adopters into the categories of innovators, early adopters, early majority, late majority, and laggards. This is the source of the categories that Moore (1995) used in his work *Crossing the Chasm* (1995) that Norman (1998) so aptly represented graphically in his work *The Invisible Computer*, which has been further modified to address the issues discussed in this article (see Figure 1). The chasm is the shift in market-driven acceptance (or consumerism) as customers drive the life cycle of innovation, not the inventors or innovators.

Figure 1 identifies the life cycle of an innovation. In the early days, the innovators and technology enthusiasts drive the market; they demand technology. In the later days, the

pragmatists and conservatives dominate; they want solutions and convenience. Note that although the innovators and early adopters drive the technology markets, they are really only a small percentage of the market; the big market is with the pragmatists and the conservatives (modified from Moore, 1995).

The Relationship of Life Cycles to Technology Studies

Technology exists today to accomplish prototyping phase tasks in the shortest time frame possible. Future life cycle phases are dependent on an accurate information model, as well as an accurate physical model. Change history, design review documentation, test results, material disposition, and other configuration information must be captured during this phase and made accessible to the appropriate personnel. Plans to transfer products from one life cycle phase to the next must also be documented and maintained. An easy-to-use configuration and change management tool is essential in laying a solid information foundation and reducing time-to-market.

Further evidence of the need to teach life cycles in technology contexts is provided by the Environmental Protection Agency (EPA), which according to Kenneth Stone, life cycle assessment team leader at the National Risk Management Research Laboratory for the U.S. EPA in Cincinnati, Ohio, is internally placing heavy emphasis on developing and implementing decision-making tools based on life cycle assessment (LCA). The EPA has found instances where a technology intended to reduce wastes has created unanticipated

impacts in other media and/or stages of the life cycle. LCA is being developed as a means to identify and deal with these impacts before they occur. LCA differs from other pollution prevention techniques in that it views all the resource and energy inputs to a product (life cycle inventory), as well as the associated wastes, health, and ecological burdens (impact assessment), and evaluates opportunities to reduce environmental impacts (improvement analysis) from cradle to grave. LCA is often confused with other assessment tools, such as the U.S. Department of Defense's life cycle cost (LCC), which is sometimes referred to as "environmental life cycle costing." However, as the term is applied by the EPA and the international community, LCA is significantly different from these techniques (Stone, 2000).

The Challenge of Dealing With the "Moving Target" of Technology

As we look at preparing a technologically literate individual for a world quite beyond our imagination, we must go beyond the surface definition of a person's ability to use, manage, assess, and understand technology. We must provide a curriculum that is accountable to a literacy commitment that ensures that all learners "understand, in increasingly sophisticated ways that evolve over time, what technology is, how it is created, and [most important] how it shapes society, and in turn is shaped by society" (Technology for All Americans Project, 2000, p. 9).

Our challenge and commitment to our students must be to provide opportunities for relevant content in "learner contemporary" contexts. From a curriculum development perspective we must cast off our conservative curriculum cloaks and provide energizing courses and programs that challenge both our students and faculty. We have observed that our students live "in three worlds; the natural world, the social world, and the designed world" (Technology for All Americans Project, 2000, p. 140). We must, for relevancy and programmatic survival, link, at minimum, the social and designed world in our curriculum efforts in a creative and bold fashion. To continue to "stay the course," providing traditional approaches to curriculum

development and delivery, will deprive students of creative and relevant subject matter that is dynamic, meaningful, and much needed by those individuals who will leave an indelible mark on our society.

To prepare ourselves and our students to deal with technology in the new millennium, we should begin the process of addressing the ramifications or impacts of these aforementioned concepts. Perhaps courses across the curriculum could be developed, such as Theological Implications of Technology or Biological Implications of Technology—or, possibly, curricula could be developed that help students become experts at customer service/interaction. We have to address what it means to be human because, after all, it is humans who will determine where our technologies go.

As technologists and educators in technology, it is our obligation and responsibility to take the initiative and at least consider organizers such as the ones presented here as a new way of thinking about technology. We owe it to our programs. The moral implications could be staggering. We may be approaching the point where the human form will be nothing more than simply a vessel to carry a preprogrammed silicon chip! Is it not our duty to provide the forum for understanding of these technologies—an essential component of sound decision making?

As technologists, we need to make a commitment to profess the virtues of spiritual growth, adaptation, and human development or performance improvement as opposed to focusing solely on the technology itself and fanning the fires that represent the manifestation of perhaps losing touch with what it means to be human. If we really wish to prepare ourselves for the future we have to be willing to shake off those prejudices of the past that have come to be so ingrained in our culture and look at our opportunities and challenges through a clear lens. We can't affect the future if we're not prepared to face the future.

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What Is Technology Transfer?

Technology transfer is a process in which knowledge, cost, risk, and benefit are shared among various economic entities in modern human society (Song, 1998). These economic entities include the inventors who are the creators and intellectual owners of the intellectual properties that comprise the actual inventions; the legal owners of the inventions who can be the inventors and, sometimes, the inventors' employers and/or the assignees; the manufacturers and the commercial distributors (who are sometimes the inventors themselves), who convert the invention into a tangible commodity; and, finally, the users of the inventions including governments and private entities as well as individual consumers of the general public (Song, 1998).

Why Technology Transfer?

We continue to live in an era where knowledge is created, updated, and shared commercially as any other commodity. In fact, knowledge is deemed as a great source of business power, and the "management of knowledge" is of serious concern to leaders in industry today (Greco, 1999). From both an American and global perspective, the transfer of knowledge, most commonly the new findings and discoveries associated with rapidly changing technologies, has assumed greater importance than ever before (Anonymous, 1998; Walumbwa, 1999). The need for technology transfer as a professional practice as well as an academic discipline for faculty and students in technology studies can be examined in terms of (a) professional obligations and (b) legal mandate and socioeconomic significance. This may, in turn, create a new paradigm shift in evaluating faculty and student scholarship.

Professional Obligations

Technology faculty and students majoring in technology are key human resources in carrying out the mission of a university, that is, to transmit (via teaching and learning), create (via research), and apply (via public service) knowledge. The transmission, creation, and application of knowledge are interrelated, and many institutions would even prefer a synergistic

relationship where the whole becomes greater than the sum of the individual parts. The increasing emphasis on research sometimes raises the issue of added responsibility for universities in terms of serving the community by communicating the results of their research efforts expediently, particularly those findings that could positively impact the lives of people.

The following examples of 1998 and 1999 award-winning research in the nation's prestigious annual Collegiate Inventors Competition (1999; also earlier known as the B.F. Goodrich Awards Competition) shed some light on potential societal and economic implications of university research:

- Amtek Phase-Change Incubator for Use in Areas Without Electricity
- Twistmaster, a Jar-Opening Device for People with Disabilities
- Pendeo-Epitaxial Growth of III-Nitrides for Use in Microelectronic Devices
- Luminescent Quantum Dots for Ultra-Sensitive Biological Detection
- Planing Hull Catamaran Designed to Plane on the Water Rather Than Displacing It
- A New Dynamic Random Access Memory (DRAM) Cell
- Phosphouminoglycosides: Potentially Curative Strategies of Chemotherapy for End-Stage or Hormonally-Refractive Cancer
- Jeep Rear Suspension
- Method and Apparatus for Selectivity Inhibiting Activity in Nerve Fibers

Although the inventions profiled in the Collegiate Inventors Competition represent only a small sampling of research at our universities, the national stature of the award reflects both the range of academic disciplines and the magnitude of their potential social and economic impact.

The Legal Mandate and Socioeconomic Significance

Technology transfer has become more relevant to university faculties and students since 1980 when the Bayh-Dole Act (P. L. 96-517; subsequently amended in P. L. 98-620), passed by Congress in 1980, established a uniform federal patent policy that encourages

universities to retain title to inventions even though they are developed through governmental funding. The Bayh-Dole Act is the single most significant stimulant to university technology transfer activities. Historically, about 60% of all university research funding comes from government sources (Thayer, 1992). The universities are mandated to file patents on inventions they elect to own, while the government retains march-in-rights and a nonexclusive license to practice the invention throughout the world. More information on the Bayh-Dole Act and subsequent legislation may be accessed via the Internet from <http://web.mit.edu/osp/WNW/cogr/cogr.html> (The Council on Governmental Relations, 1993) and <http://www.ucop.edu/ott/tech.html> (Office of Technology Transfer, 1998).

Most recent statistics indicate that more than 7,000 invention disclosures per year are being filed by individual faculty members at U.S. universities, resulting in more than 5,000 patent applications per year by the universities. Subsequently, more than 2,000 licenses and/or options per year are executed, yielding an annual royalty income of approximately \$300 million for the inventors and their universities nationwide (Song, 1998). The financial implications of new discoveries and inventions continue to be a major force in promoting continuous expansion of the research function at U.S. universities and, for that matter, universities worldwide (Anonymous, 1999; Bell & Sadlak, 1992; Blumenstyk, 1998; Kenward, 1986; Sales, 1997; Waugaman, 1990).

Technology transfer and commercialization, facilitated by the Bayh-Dole Act, have positively impacted the lives of the general public in several ways. New drugs, medical treatments, building materials, consumer products, diagnostic devices, and innovative application software are just a few of the products that started as ideas in university research laboratories and now touch our lives daily (Northwestern University Infrastructure Technology Institute, 1998).

The success of the Bayh-Dole legislation is reflected in the number of patents awarded to universities annually before and after the bill was passed. A decade after the bill was passed, about 1,600 patents were issued annually to university inventions as opposed to only about 250 prior to the legislation (Office of Technology Transfer, 1998). In 1996 alone, 248 start-up companies were formed because

of new technologies transferred from university inventions (Song, 1998). The wealth-generating potential for faculty research is one of several important reasons why most universities nationwide have established their own offices of technology transfer (OTT) to handle faculty and student inventions.

Faculty and Student Innovation and Creativity: Need for a Paradigm Shift

With rapid advances in technology, particularly with the proliferation of computer-based applications, scholarly and creative work can emerge in a format that is not universally perceived as being conventional. A number of higher education institutions continue to have a restrictive definition of scholarly work, often limited to journal publications, books, and selected conference proceedings and presentations. The current generation of faculty and students have the resources and opportunity to bring forth their creativity and innovation in the form of other copyrighted materials including computer programs and computer-based instructional materials on CD-ROMs and the Internet as well as patents, trade-marked laboratory materials, and technical processes deemed as trade secrets. For a long time, the American public has acknowledged inventors' rights to benefit from their creativity as society continues to benefit from their new discoveries (Fleming, 1991). University faculty and student inventors are no exception.

Technology Transfer Process for Faculty and Student Inventors

Faculty members and students in technology studies are most likely involved in the technology transfer process as either the inventors or intellectual property consultants. Figure 1 is a flowchart that includes three major actions (A1, A2, and A3) and seven decisions/determinations in a typical technology transfer process involving university faculty and students, where D1 is a legal and ethical decision by the inventor based on the inventor's employment conditions; D2 is a personal decision by the inventor based on the inventor's knowledge of, interest, and confidence in pursuing the technology transfer process as the intellectual property owner; D3 is a research, technological, and business decision by the inventor's based on the nature of the invention itself and its potential market analysis; D4 and

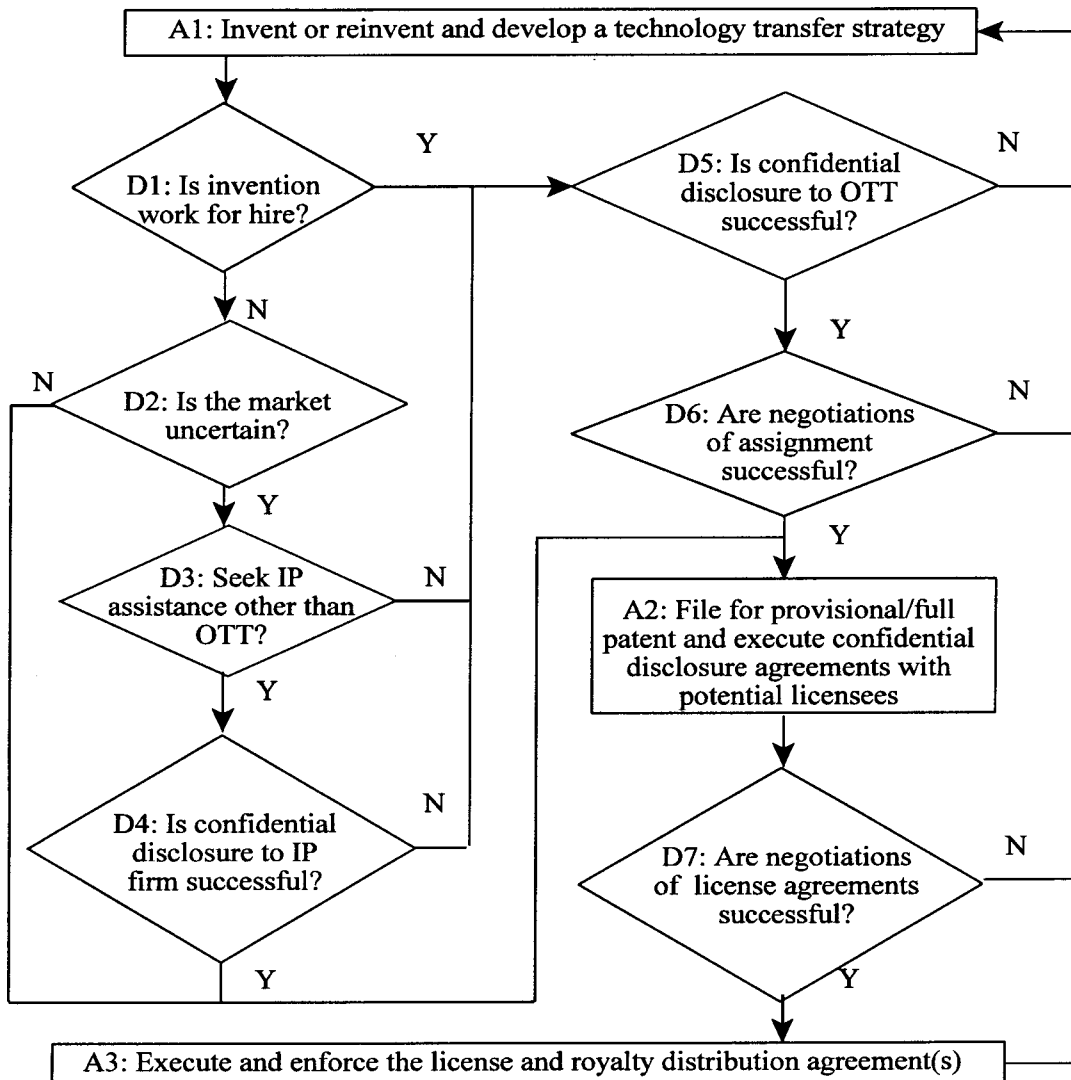


Figure 1. Technology transfer process for faculty and students in technology studies.

D5 are determinations of the matching of interest, resources, and perceptions between the inventor and potential assignees of the invention; D6 is a determination of an appropriate match between the inventor and the potential assignees in terms of their interest, resources, and perceptions of the invention itself and its potential market; and D7 is the determination of a match between the owner of the invention (either the inventor or the assignee at this point) and the potential licensee in terms of interest, resources, and perceptions of the invention itself and its potential market, as well as production and marketing costs, market uncertainty, and royalty rates, all being a function of time within the life of the technology.

Intellectual Property Rights and Infringement Issues

The intellectual property rights and infringement issues in the case of a patent are thorny in technology transfer processes. Generally, the inventor owns the intellectual property residing in his or her invention unless the invention is part of the work for hire. If an employer contracted the work, he or she is the owner of the intellectual property or the patent for the invention. In all the cases, the inventor's name will be listed as the inventor in a patent certificate, on which the ownership will also be specified. An infringement of the patent occurs when a patented technology is used for commercial purposes without the authorization of the patent owner.

Patent infringement cases can be normally settled in or out of a federal court. Remedies are determined by the estimate of the actual monetary loss to the patent owner due to the infringement. The principles of microeconomics and market research data are often considered in the determination. Considering that an invention is patentable in the United States only if it is novel, nonobvious, and useful, a patent infringement case always involves the question about whether the patent is valid in the first place. The risk and costs involved to a patent owner in a patent infringement case are often considerations that lead to a settlement outside the court. Interested readers may visit <http://www.ceet.niu.edu/faculty/song/tco> for more information and references on the thorny issue of intellectual property rights and infringements.

Need for a Technology Transfer Curriculum

Aristotle (384-322 BC), the Greek writer and philosopher, once said that an exclusive sign of thorough knowledge is the power of teaching. Successful technology transfer practice draws upon the knowledge and skills from a variety of disciplines including but not limited to technology, business, law, and liberal arts and sciences. Technology transfer is implicitly interdisciplinary, lying on the border of many traditionally divided academic territories. It is not surprising that very few universities offer a course exclusively devoted to technology transfer. As business-oriented technical professionals, industrial technology educators are among the most qualified professionals capable of teaching courses that exclusively address the essentials of technology transfer. At the same time, current market trends also suggest that our graduate students should possess adequate skills to work in today's virtual and real "global villages" where technology transfer is ubiquitous. Therefore, a course in technology transfer as a core requirement appears to be a timely addition in all graduate degree programs in technical studies and allied areas.

Previous research has called for an expansion of the content base even among those few schools that currently do offer a course in technology transfer or closely related area (Johnson, Gatz, & Hicks, 1997). A significant number of graduate (master's and doctorate level) programs exist in industrial technology, industrial education, technology education, and related fields; yet, very few

programs offer a course in technology transfer, particularly with an emphasis on universities as the "creators and exporters of technology." The issues of technology transfer are of high relevance even among community colleges across the nation (Bragg et al., 1991; Spaid & Parsons, 1993; Sugarman, 1992). The proposed university course could be tailored to meet the needs of faculty and administrators at community and other junior-level colleges. Because programs leading to terminal degrees in technical studies often include preparation of future community college educators as a major goal, we have here another good reason to offer a course in technology transfer.

A Feasible Technology Transfer Curriculum and Its Clientele

The diverse range of topics embraced by technology transfer makes it a rather complex subject matter for undergraduate instruction. Therefore, it should be taught only as part of the graduate curriculum. A one semester class that meets for three hours every week should provide a reasonable platform for educating technology studies majors in the essentials of modern-day technology transfer. The unique aspect of our course proposal is the emphasis on topics that are likely to help students during their academic as well as lifelong careers. Our course consists of three modules that may also be treated as three stand-alone courses, each worth one semester hour of credit. These modules should be taught in sequence for maximum effectiveness. It should be recognized that one-credit courses (nicknamed "sprint courses") can often find their way into a curriculum and be implemented with more ease than a typical three-credit course (Bardes, 1996). The modules are (a) General Concepts, Practice, and Procedures of Technology Transfer; (b) Engineering Economy and Market Research in Technology Transfer; and (c) Case Studies of University Faculty and Student Inventions.

Module 1—General Concepts, Practice, and Procedures of Technology Transfer will develop a historical backdrop focusing on the economic and social impact of technology development and transfer in the United States. The overview will include an introduction to federal, state, and local development strategies and initiatives, and will discuss issues involved in policy development and benchmarking. Concepts and procedures for assessing/

identifying originality, utility, nonobviousness, and the level of “proof of concept/reduction to practice” required for patenting and prototyping of inventions will be covered. Information presented in Module 1 will be organized to provide both a historical perspective of the innovation/transfer process and a contextual framework and continuity for the information presented within the other modules. Internet tools for patent searches along with the fundamental concepts and procedures of intellectual property protection will also be presented.

Module 2—Engineering Economy and Market Research in Technology Transfer will introduce strategies for invention market research via a computerized database and market survey procedures, computerized statistical and cash-flow modeling of inventions, decision making (involving risks and uncertainties), decision-making trees, and contemporary strategic planning/decision-making tools to be used in the technology transfer process.

Module 3—Case Studies of University Faculty and Student Inventions will include cases of student inventions in recent American history involving all areas of science, engineering, and technology. Each case will be revealed in terms of the inventors’ personal and academic background, the fundamental science, engineering, and technology principles involved, and the existing and/or potential scientific, economic, and humanistic impacts. The socioeconomic relevancy of undergraduate science, engineering, and technology courses will be discussed, and the student inventors will serve as role models for all undergraduate science, engineering, and technology students nationwide. The case studies should be developed via a systematic literature review and news screening of the past decade, complemented by a fresh survey of U.S. universities currently published by the Association of University Technology Managers.

Curriculum Clientele

The audience for this course should be graduate students or senior undergraduate students having outstanding credentials. Majors from several disciplines including general sciences, engineering, technology, and even liberal arts, fine arts, and social sciences will learn something valuable from the proposed course. A patent may be obtained

on an idea that has its roots in almost any subject ranging from algebra to zoology. A quick navigation to the IBM Patent Databank will reveal the fact that a large percentage of the U.S. patents issued in the past 20 years consist of inventions in the field of humanities and arts (IBM, n.d.). Innovative and practical ideas stretch across traditional disciplinary boundaries and, accordingly, the topics included in the proposed technology transfer course should be of interest to diverse groups across college campuses.

The proposed technology transfer curriculum will stimulate the appreciation, understanding, and enthusiasm of undergraduate students from various disciplines for technology innovation, development, and transfer process, and also show how they can become personally involved. The singular feature of academic diversity of the technology transfer course should attract significant attention and enrollment to the field of technology studies, a field which is interdisciplinary by nature and still deserving of its own unique academic and professional niche.

Implications and Questions to Technology Studies as a Discipline

Georg Hegel (1770-1831), a German philosopher, once observed that just as we do not need to be shoemakers to know if our shoes fit, it is not necessary for us to be a professional in order to acquire knowledge in matters of universal interest. A case may be established that knowledge of technology transfer is a matter of universal interest. This article along with the curriculum it proposes to faculty and students in technology studies aims at improving the preparation of future technology educators and practitioners by offering an opportunity to understand effective strategies to transfer ideas. Since no single academic group has, so far, made large-scale claims on its exclusive rights to “technology transfer,” this is an opportunity waiting to be exploited by faculty affiliated with technology studies. There is no telling how long this opportunity could last. If faculty members and students in technology studies become more active players in technology transfer as inventors, intellectual property managers, and technology transfer educators, wouldn’t the status of technology studies as a discipline be elevated to the next higher level? William Gull

once remarked that the road to medical knowledge is through the pathological museum, and not through an apothecary's shop (Wilkins, 1991). Perhaps the road to technical knowledge is through the patent database, and not through a school laboratory. This may be especially true to the future scholarship of faculty and students in technology studies.

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How Nontraditional Bachelor of Science Degree Technology Students Perceive Distance Learning

Dale E. Thompson, Betsy Orr, and Cecelia Thompson

This is a report of a questionnaire survey of 27 students. The intent was to determine their perceptions of distance education classes taken during a bachelor of science degree program designed for adult off-campus students. These distance education classes were offered by interactive audio and video transmissions at a set time to as many as five remote sites. The questionnaire covered:

1. Student learning—self-rated levels of learning and understanding of course content.
2. Instructional techniques—instructor's use of lecture, handouts, and visuals; instructor's ability to encourage students to participate and reflect.
3. Medium—how the technology affects the pace of the class, the quality of transmission, and how different sites interact.
4. Attitude—self-rated feeling about preferences for distance education instruction.
5. Possible uses of distance education—students' view of future uses of distance education.

Other studies and experts' views of the preceding areas are presented in the following discussion of distance education. This is followed by a brief report of our study that includes a description of the student group, their program of study, the questionnaire, and what we learned.

A Description of Distance Education

"Distance education can best be described as the separation of student and instructor during the process of education delivery" (Swift, Wilson, & Wayland, 1997, p. 1). Distance education allows students to be in different geographic locations and receive instruction from the teacher at the same time. Steiner (1999) identified the defining elements of distance education as "the separation of teacher and learner during at least a majority of each instructional process and the use of educational media to unite teacher and learner and carry course content" (p. 1).

Many distance education programs are designed to meet the needs of the

nontraditional adult learner. The proportion of college students who are adult learners has been increasing steadily. Fewer than one in six undergraduates fit the traditional stereotype of the American college student: 18 to 22 years of age, attending college full time, and living on campus (Gatien & Griffiths, 1999). Adult learners are different in many ways. They differ in their view of the world, how they make judgments, and how they form values (Hand, 1992). There is wide acceptance of individual differences in ability, motivation, values, attitudes, and personality of adult learners (Perry, 1994).

Areas Affecting Distance Education

Our literature review identified five areas that affect the success of distance education: student learning, instructional techniques, medium, attitudes, and possible uses of distance learning.

Student Learning

Smith (1994) reported that students rated distance education courses similar in quality to traditionally taught courses; however, students and faculty members indicated a preference for conventional instruction over distance education. In his study at a technical college, Hogan (1998) found that distance learning students' grades were .27 points higher than those in traditional courses and that distance learning students had higher completion rates than traditional students. Koch (1998) also found that distance learning students earned higher grades than did students in traditional courses.

Shneiderman, Borkowski, Alavi, and Norman (1998) found that students rated their learning effectiveness in the distance education classroom significantly higher than in the traditional classroom. However, Tregust, Waldrip, and Horley (1993) found no statistically significant differences in student learning when comparing distance education courses with regularly scheduled courses.

Instructional Techniques

Sherry, Fulford, and Zhang (1998) examined the opportunities for students to

interact with instructors and other students in distance education and traditional classrooms. In distance education, students perceived instructor-to-class interaction as positive and moderately correlated with the perception of learner-to-learner interaction. Students enrolled in distance education classes compared to students in traditional education courses indicated learner-to-instructor and learner-to-content interactions as important. Both groups indicated overall support for small group process. This indicates the need for faculty to visit each remote site at least once during the course, ensuring that all students have "in person" time with the instructor (Swift et al., 1997).

Faculty members who teach by distance education must utilize a variety of teaching methods such as lecture, seminar-style discussions, case analyses, group presentations, individual presentations, video case studies, and computer demonstrations (Case, Gutknecht, Pickett, & Wilson as cited in Swift et al., 1997). Willis (1993) offered several instructional techniques needed to effectively teach by distance education:

1. "Hands-on" training with the technology used to deliver instruction is critical for both teacher and students.
2. The teacher must learn about students' backgrounds and experiences; discuss rules, procedures, guidelines, and standards; and consistently uphold procedures.
3. The teacher should contact each site or student every week.
4. Students must give regular feedback regarding course content, delivery problems, and instructional concerns.

The instructional techniques used in distance education may be a distraction for students at the host site.

Host site students were quite clear about their dislike of attending a distance learning classroom. One possible recommendation would be to simply do away with the host site group. The instructor could then focus entirely on students at the remote sites, and host site students could attend traditional classroom courses without any of the distractions caused by a distance learning course. (Thomerson & Smith, 1996, p. 46)

Medium

The technology used to make distance education available to remote classrooms can affect the classroom environment and create problems for student learning. In one study,

students reported that they liked the multimedia hands-on capabilities of the electronic distance classroom; however, factors such as quality of transmission and capability of equipment could create problems (Shneiderman et al., 1998).

In a similar study, distance education students rated statements dealing with the learning environment lower than students in a traditional classroom. They had difficulty hearing at their remote sites and the equipment caused many problems, which disrupted the class. Class time was lost while equipment was adjusted to bring all sites on line (Thomerson & Smith, 1996).

Attitude

Shneiderman et al. (1998) found that students were highly satisfied with their experiences and indicated that they would take another distance education course. He also found that technology-enhanced learning could lead to statistically significantly higher levels of perceived skill development, self-reported learning, and evaluation of classroom experiences as compared to collaborative learning in a traditional educational setting.

In a study of 288 undergraduate college students in distance education classes at remote sites, students reported overall satisfaction with the courses (Biner, Welsh, Barone, Summers, & Dean, 1997). This study supported the contention that remote site group size affects both the satisfaction and motivation of students enrolled in distance education college-level courses; larger classes were associated with more negative student attitudes, as well as with lower levels of relative performance. Other authors have reported that often students feel isolated, leading to negative feelings (Galusha, 1998; Wolcott, 1996).

There are no significant differences with satisfaction of distance education courses between men and women according to Koch (1998). He also found that students' age, marital status, or major were not related to students' anxiety toward distance education.

Pugh and Siantz (1995) assessed student satisfaction in a study between two university campuses (host sites) and between a university campus and a business location (remote sites). The instructor alternated between the two sites. This study found that the students preferred the host-site location to the remote site.

Possible Uses of Distance Education

Distance education technology may be used to link students with interest groups such as community service groups or professional organizations. Business, educational, and scientific experts can be connected to distant sites without leaving their work locations and clients (Musial & Kampmueller, 1996).

Educators must help all students become adept at distance interaction. The skills of information gathering from remote sources and of collaboration with dispersed team members are central to the future of the American workplace (Dede, 1996). Chute, Thompson, and Hancock (1999) stated that information resources will be everywhere, often separated from learners. Distance learning will be the bridge between learners and these resources.

The Study

Student Group

Twenty-seven students were enrolled in our distance education degree program at the University of Arkansas. All students were working full time as instructors at technical schools. Their technical areas were automotive technology, computer technology, culinary arts, diesel technology, electronics technology, machine technology, and nursing. The students were pursuing a bachelor's degree in vocational education.

Eight classes in the degree program were offered by interactive audio and video transmissions to seven sites in Arkansas. The class size at each site ranged from one to eight students. All of the students completed at least two of the classes offered by distance education. Approximately half of the students completed eight classes. All of the students agreed to participate in this study.

Program of Study

The distance education classes were part of the requirements for the bachelor's degree. In addition to the eight distance education classes, the students were required to complete 56 credits of general studies, 33 credits of technical requirements, and additional electives. The majority of credits were taken as traditional classes at a local college or university. The classes offered by distance education were Advanced Strategies in Technical Education, Analysis of Teaching in Technical Education, Curriculum Selection and Selection of Use in Technical Education, Surveying Special Student

Populations in Technical Education, Use of Student Resources in Technical Education, Advanced Management in Technical Education Programs, Current Trends and Issues in Technical Education, and Tech Prep in Technical Education. Five different professors taught the distance education classes.

Questionnaire

A 42-item questionnaire, adapted with permission from Treagust et al. (1993), was used to measure perceptions of the students. They were asked to rate their perceptions of student learning, instructional techniques, medium, attitudes, and possible uses of distance education using a 5-point Likert scale. Treagust et al. found reliability coefficients on the five areas ranging from 0.63 to 0.93, indicating that the areas have an acceptable reliability. A total of 27 usable questionnaires were returned for a response rate of 100%. Of the 27 students, 7 were female and 20 were male. Ages ranged from 25 to over 55 with the majority in the 45 to 54 age group.

The data were analyzed using the SPSS for Windows statistical software package. Mean score and frequency calculations were compiled for the five areas. Variables of interest were gender, age, size of class, and number of distance education classes completed.

Findings

Perceptions of all five areas of distance education were positive with possible uses of distance education having the highest mean score (see Table 1).

Table 1. Means of Areas of Distance Education

Area	Mean
Student learning	3.8
Instructional techniques	4.0
Medium	4.3
Attitudes	4.2
Possible uses of distance education	4.4

The specific statements that received the highest mean scores (> 4.5) in rank order were:

1. Distance education provides opportunities to take courses that may not normally be available (mean = 4.7).

2. I enjoyed having the opportunity to learn how to use distance education techniques (mean = 4.6).
3. Distance education would be an effective way to conduct professional development programs for professional people (mean = 4.6).
4. Distance education is a good form of learning for remote/rural students (mean = 4.6).
5. Distance education would improve access to learning for remote/rural students (mean = 4.5).
6. If I had known what was involved in the use of distance education I would have changed to another class (mean = 4.5).
Note: Scores were reversed.
7. Distance education would be an effective way to conduct vocational education courses for people in the workforce in remote/rural areas (mean = 4.5).
8. Distance education would improve access to professional development/training for remote/rural workers (mean = 4.5).

Examining the variables of gender, age, size of class, and number of distance education classes completed, it was found that females, students over 55 years of age, and those completing more classes had a slightly more positive perception of all areas of distance education.

The areas rated the lowest were student learning and instructional techniques. The technology of distance education limits classroom interaction, the amount of content covered, kinds of instructional techniques used, and interpersonal relationships with the instructor and students at other sites. All of these affect students' perceptions of learning and instruction.

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The students in our study felt very positive about the medium. They quickly learned to use the electronic classroom and were not intimidated by the technology they were required to operate—control board for cameras, microphones, computers; video projection equipment; computer access and television monitors.

This program with distance education classes offered these students an opportunity to complete a bachelor's degree. Because of their rural locations throughout Arkansas, this was their first opportunity to complete a degree without long travel time or relocation. These students recognized the value of the program for themselves and the positive future use of distance education.

Our study shows the importance of using distance education as an avenue for the completion of a university degree. There are many adults in the workforce who value degree completion but are unable to make the sacrifice to attend university classes. Distance education, whether interactive classes or web based, combined with traditional classes offers this opportunity.

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Learning Styles: Teaching Technology Subjects Can Be More Effective

Ronald I. Sutliff and Virginia Baldwin

Learning style theory has been developed and applied in various curricula for all levels of education. Kolb (1985) developed one particular method of assessing student learning style. The use of this method has been documented in the engineering and technology programs of several universities. Variations in learning style due to cultural diversity have been studied and are described in the literature.

This article describes and recommends the use of learning style theory to assess individual learning styles in the classroom and the use of teaching methods to accommodate various learning styles. Sutliff (one of the authors) administered the Learning Style Inventory (LSI) to his computer-aided drafting class in the School of Technology at Eastern Illinois University. Results of this study are offered here, as well as examples drawn from the literature, to show the potential helpfulness of this process in accommodating the various learning styles of students of engineering and technology, including those that result from cultural diversity.

The Teacher/Learner Relationship

Miller and Rose (1975), two prominent vocational-technical teacher educators, insisted that two truths must be recognized in class: all students differ and the teacher is often unaware of how they differ. The professional teacher should consistently observe students, listen to students, and try to understand each student. Personal differences of students need to be considered and the instructional delivery system needs to correspond to the varying abilities of the students. Bartel (1976) insisted that regardless of the teacher's abilities, including being an expert in his or her technical field, failure to learn will occur unless an understanding of the personal differences among students is known and teaching proceeds accordingly.

Kirkpatrick (1983) offered a three-step model to make teachers' presentations more meaningful: (a) present the material, (b) personalize the material, and (c) allow the students to interact with the material. If the material is just presented without an attempt to personalize it and have students interact with it, there is a strong possibility that the material

presented will not be understood by the students. Students may not grasp the material even though it is well organized, technically adroit, and replete with creative visual aids.

Belay (1992) also invites educators to view cultural differences as another opportunity to conceptualize the learners as unique persons. He cited a growing body of knowledge that suggests several differences between cultures in cognitive processing and problem solving.

Too often, the teacher tends to view the classroom as one bifurcated between teaching and learning. Students may fail to learn the material because the teacher's style of teaching does not match the learner's style of learning.

Models for Adapting Instruction

Green and Parker (1989) proposed a sophisticated conceptualization of the learner and suggested a model that could enable teachers to adequately adapt their instruction to the unique needs and behaviors of their students. The model was Kolb's (1984) experiential learning model. Developed and fostered by Kolb in 1984, this model was originally based on experiential learning theory that integrated the cognitive and socio-emotional factors in learning. Throughout the years, there have been some modifications and enhancements to the model since it was introduced (Cornwell & Manfreda, 1994).

Kolb's original model consisted of a cyclical process involving four stages (see Figure 1) that included (a) concrete experience (CE), (b) reflective observation (RO), (c) abstract conceptualization (AC), and (d) active experimentation (AE).

The concrete experience stage of the learning cycle stresses personal involvement with people in daily situations. In this stage, the learner tends to rely on feelings rather than on a systematic approach to situations. In a learning setting, the learner's ability to be open minded, flexible, and adaptable to change would be important. People in this stage of the cycle learn from feeling. The learner would learn from specific experiences relating to people and would be sensitive to their feelings. To accommodate this learning mode, the teacher would include personalized teaching activities.

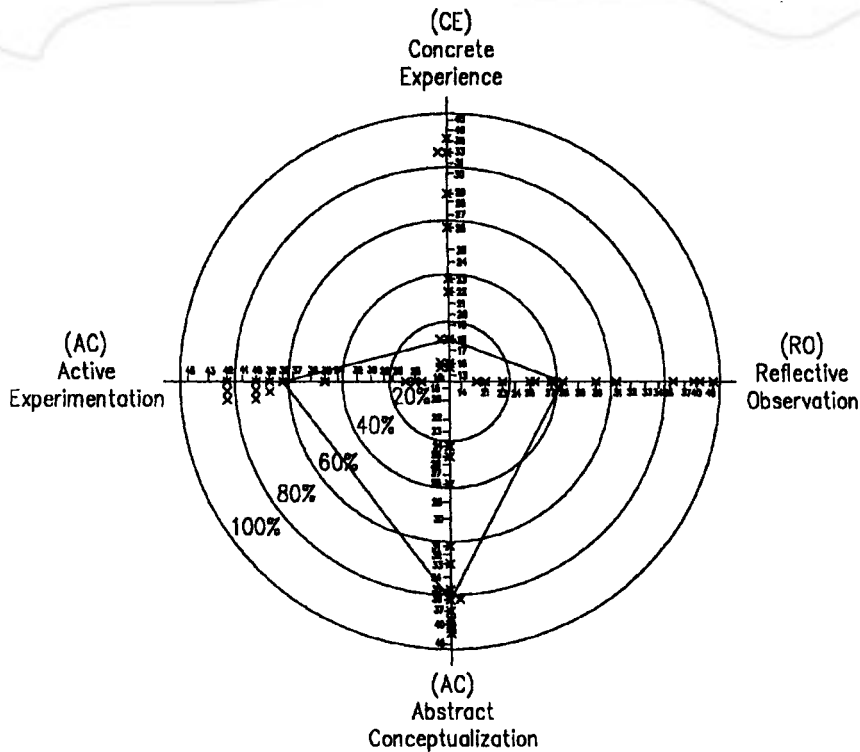


Figure 1. A student's learning style inventory scores are plotted on the diagram to get a "kite-like" shape.

In the reflective observation stage of the learning cycle, people group ideas and situations from differing perspectives. In a learning setting, the reflective observer would rely on patience, objectivity, and careful judgment. These learners depend on their own thoughts and feelings in creating their opinions. In other words, in this stage people learn by watching and listening. They would carefully observe before making decisions. They view issues from different points of views and look for the meaning of things. The learner in this stage needs to be provided with opportunities for reflective exercises.

In the abstract conceptualization stage a person's learning involves using logic and ideas, rather than feeling, to understand problems or situations. Typically, this learner relies on systematic planning and develops theories to solve problems. These people logically analyze ideas, systematically plan, and act on their intellectual understanding of a situation. This type of learner needs time to analyze the information presented.

In the active experimentation stage, learning involves experimenting, influencing, or changing a situation. Active experimenters take a practical approach and are concerned with what practically works rather than simply

observing a situation. They value getting things done and seeing the results of their influence and creativity. This person learns by doing and has the ability to get things done. Active experimenters are definitely risk takers and influence people and events through action. To accommodate this mode in a learning situation, students are allowed many opportunities for "hands-on" activities. There is no single mode that completely describes a person's learning style. In reality, each person's learning style combines some, or all, of these learning modes (Kolb, 1985).

Optimally a teacher uses various types of learning strategies even if there is a dominant learning mode in class. Retention may be increased when a teacher addresses all learning modes. Stice (1987) found a similarity between the increased learning retention resulting from movement through all four stages of the learning cycle and the increased retention when auditory, visual, and kinesthetic methods of learning are employed together.

Kolb's model assumed that active experimentation (AE) and reflective observation (RO) are opposite modes and that abstract conceptualization (AC) and concrete experience (CE) are opposite modes (see Figure 2). By crossing or combining the four learning modes,

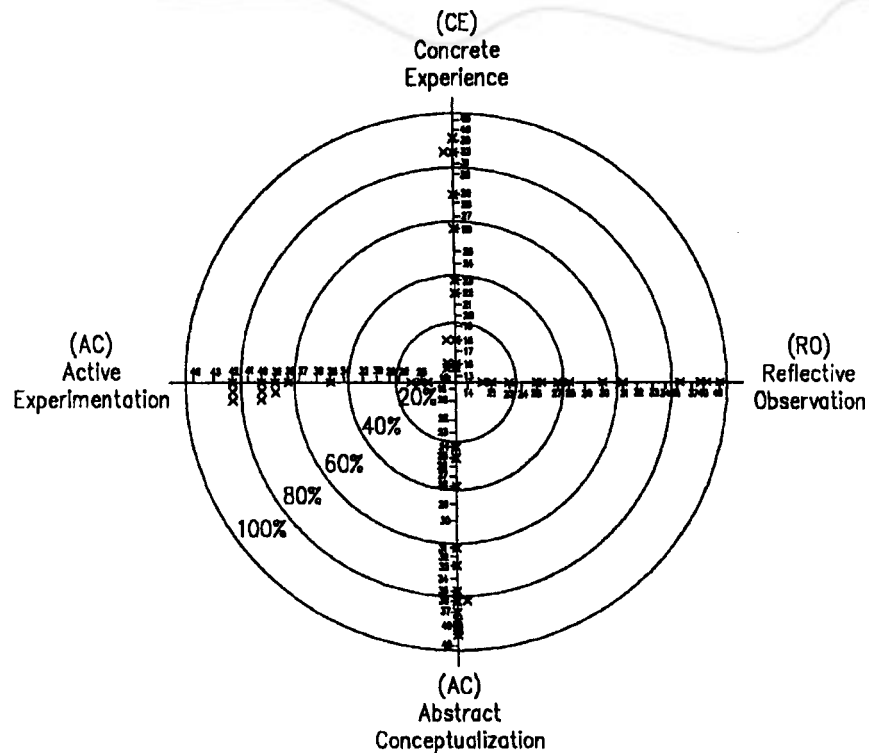


Figure 2. Plot of the scores of 13 students in a computer-aided drafting class.

four *learning style types* can be defined as follows:

- Accommodators—active experimentation combined with concrete experience.
- Convergers—active experimentation combined with abstract conceptualization.
- Assimilators—reflective observation combined with abstract conceptualization.
- Divergers—reflective observation combined with concrete experience (Kolb, 1985).

Kolb's Learning Style Inventory

The Learning Style Inventory (LSI) developed by Kolb (1985) is a test to help the learner and teacher understand the learner's predominant mode of learning. It consists of 12 questions, beginning with three or four words, for example, "When I learn...", "I learn best when...", and "I learn by...." Respondents rank four alternative endings to the words to best characterize their learning mode. There are no right or wrong answers, but rather what is perceived as "right" to the respondent.

When the learner finishes the inventory, his or her profile forms a "kite-like" shape. The shape and placement of the profile shows the respondent which learning mode(s) he or she tends to use the most (see Figure 1).

Students' scores on the Cycle of Learning compared with other student scores are also provided in the diagram. The raw scores for

each of the four basic scores are listed on the perpendicular lines of the target. The concentric circles labeled with percentages represent percentile scores for the "normative group." The normative group score is a standard obtained by administering the test to many groups over time and getting an "average of the group averages." If a person scores 45% (i.e., 45th percentile), that would mean that 45% of the persons in the normative group scored lower. In comparison to the normative group, the shape of a person's profile indicates which of the four basic modes he or she tends to emphasize most.

Using the Learning Style Inventory in Class

In Felder and Silverman's (1988) article on using these techniques in class, they recommended talking to students about learning styles and how they learn best. We propose taking the process one step further by actually administering the LSI to members of each class taught.

Teachers who administer the LSI in their classes can better understand each student's learning style and thus adjust their teaching style to maximize the potential achievement of the students. What is equally important is that the learners understand their own style of

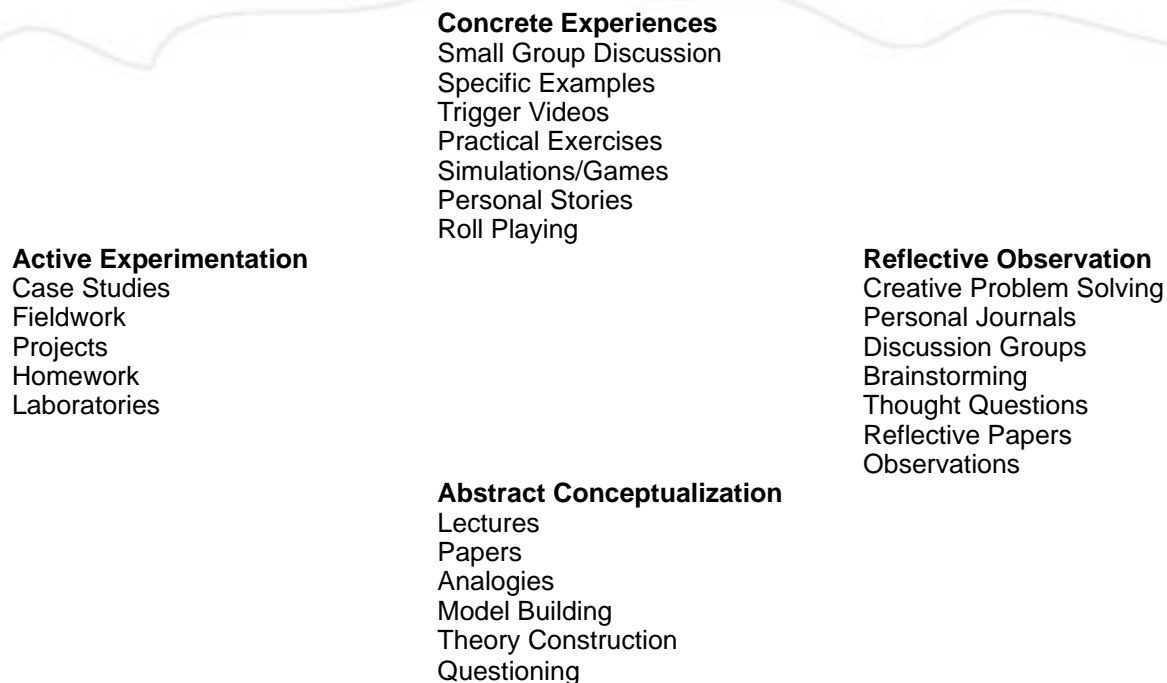


Figure 3. Instructional activities that support different aspects of the learning cycle (modified from Svinicki & Dixon, 1987, p. 142).

learning. This knowledge can increase their learning potential.

Sutliff administered the test to his junior level class of 13 computer-aided drafting students enrolled in an Industrial Technology program. The students were asked to read the instructions before starting the LSI and were allowed 10 minutes to complete the inventory. Then each student was instructed to total the four columns to get the scores for concrete experience (CE), reflective observation (RO), abstract concept (AC), and active experimentation (AE). After students totalled their scores, they plotted each score on the diagram, then connected the dots to get the kite shape. They were then informed that the shape and placement of the kite indicated which learning modes they tended toward. The entire process required 20 minutes.

Figure 2 plots the scores of 52 students. There are clusters of points outside the 60% circle for active experimentation (9) and abstract conceptualization (10). These represent 36.5% of the scores and indicate these two as the predominant learning modes in the class. The individual scores (not designated in this figure) show that only one student was very low in both modes. With that exception, all students would be accommodated if teaching methods were used that

addressed the two dominant modes.

Figure 3 (modified from Svinicki & Dixon, 1987) lists sample activities that a teacher can assign or incorporate that support the different stages of the cycle of learning. Techniques for moving through the four stages during engineering class sessions can be found in the literature. For example, Harb, Durrant, and Terry (1993) found that accommodator activities are typically lacking in engineering classrooms, especially in lower division courses. To accommodate the Kolb learning cycle, they offered samples from seven courses that typify an engineer's education (e.g., materials, chemical engineering, manufacturing) that accommodate each of the four learning style types: accommodators, convergers, assimilators, and divergers. Howard, Carver, and Lane (1996) presented a lesson plan for a structured programming course to accommodate the Kolb learning cycle and other models.

When teachers become aware of students' variations and consider the extent to which each of these preferences exists in their classroom, they can plan instruction accordingly. None of the learning-style types—accommodators, divergers, convergers, or assimilators—is inherently superior. Rather, to be optimally effective, instructors need to work through each of the four stages and use

activities appropriate for each stage to accommodate all learning styles in the class. They also need to consider what is appropriate for the course content and the learning styles that dominate their classes. Use of all four stages during a classroom session, while taking more time, will enhance students' ability to learn independently and well.

Culture and Learning Styles

Guild (1994) examined the relationship between culture and learning style and concluded that the only way to meet the learning needs of culturally diverse students would be to intentionally apply diverse teaching strategies. In addressing the issue of structuring the basic public speaking course for African American students and other students of color, Nance and Foeman (1993) suggested including open discussion and physical movement as part of instruction to correspond to the unique learning styles of African American students. Belay (1992) and Correa and Tulbert (1991) described the learning styles that are typical of "field dependent" learners and that are attributed to certain cultures such as African Americans and Hispanics. With this style, learners tend to be more concerned with their social environment and prefer to work cooperatively with others. This type of learner may have serious adjustment problems in classes that emphasize lectures, competitiveness, and individualized work environments. Teachers who adopt methods that accommodate the variety of learning styles identified by Kolb will be addressing cultural differences in learning styles in the classroom simultaneously.

Powell and Andersen (1994) presented a model for adapting instruction to the learner that connects a person's culture to a particular learning style. In their essay on culture and classroom communication, they cited many examples of how students' cultural diversity influences instructional communication in the United States. The student from an Eastern culture tends toward reflective observation—since knowledge and insight in Eastern cultures are believed to come from reflection and meditation. On the other hand, the Native American student may combine reflective observation and active experimentation since the Native American culture tends to utilize a visual learning style that is dependent on observation and imitation, rather than explicit

verbalization. In his study of the Israeli culture (with respect to the equivalency of Kolb's LSI), Katz (1988) stated that the Israeli culture is frequently characterized as aggressive, outspoken, energetic, and action oriented. The Israeli sample in his study displayed a more active experimentation orientation.

Balanced Delivery System

Kolb's model offers a system for teachers who are attempting to reach all students in their classrooms. In fact, this model can be institutionally adopted and used in the total instructional program of primary, secondary, and/or postsecondary schools to assure that all students are tested and to accommodate them personally while they are at school. The learning cycle and activities associated with the different modes definitely provide students with maximal learning and significantly reduce students' boredom and alienation. For example, teachers can lecture on the theory (abstract conceptualization); have students personally reflect on the content, ask questions, and discuss the content (reflective observation); assign homework, fieldwork, and laboratory projects (active experimentation); and direct small group discussions, give concrete examples, show videotapes, and discuss personal experiences (concrete experience). Through college curricular design, individual courses or sets of courses can take students through all four cycles.

It may not always be possible to have a completely "balanced" lesson, course, or program. The characteristics of the course often determine which particular teaching style works well with the preferred learning styles of students. For example, a laboratory course more closely aligns with the concrete learning style. A course of study can begin with assessment of students' learning styles and follow with appropriate learning experiences to "fit the class."

Developing Learning Skills

Whether or not a teacher completely subscribes to this model is not as important as becoming aware of the mix of student learning styles in a classroom and the need to "fit" instruction to student need. Presumably, the primary goal of teachers is to maximize student achievement. Selecting and combining various teaching styles, as opposed to staying with the style the teacher prefers, is an important step

in meeting that goal.

According to Sugarman (1985):

The capacity of Kolb's framework for helping people expand their repertoires of learning skills is also important. Students who are taught Kolb's ideas, both as the rationale for course design and as a model of the learning process, can conceptualize the total learning process, empathize more readily with the perspectives of students with different learning styles, and improve their own methods of learning. Although people may always prefer to learn through particular processes, they can develop their capacities in other fields. Thus, divergers can learn to give conscious attention to the applications of their observations and can realize the validity of doing so. Accommodators can reflect on their experiences and experiments. In other words, learning to learn can become an additional course objective. (p. 267)

The LSI can be used in a classroom setting to assess each student's learning style. Associated with each of the four stages of the cycle of learning are activities the teacher can use to meet both the course objectives and the instructional needs of their students. Doing so will also mitigate the learning style differences that are culturally derived as well as address the varied learning styles of students in a technical or technology program.

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Technology Education's Role in the New National Science Standards

Gerald G. Lovedahl

One of the foundations of American democracy has been its emphasis on public education. Even so, as the American Association for the Advancement of Science (AAAS, 1990) pointed out in its publication *Science for All Americans*, "most American children are not science literate" (p. xv). In fact, students remain below the levels of the 1970s in their knowledge and understanding of both science and mathematics. This fact has been documented in a number of publications beginning with the National Commission on Excellence in Education's (1983) report entitled *A Nation at Risk: The Imperative for Educational Reform*. This report cautioned that unless we reform the entire educational system we are headed for a national educational crisis. The AAAS (1990) reinforced this prediction by pointing out that American students rank far behind those from other countries in problem solving and that the average performance for 17-year-olds is now worse than almost three decades ago.

In response to the immeasurable reports citing the poor performance of American students in science and mathematics, the AAAS initiated Project 2061 in 1985 to reform science, mathematics, and technology education for the 21st century. This project proposed "a fundamental reformation of science, mathematics, and technology education" (AAAS, 1995, p. 6). According to the AAAS (1995), current science textbooks and teaching methods do not encourage working together, sharing ideas and information, or using modern instruments to extend intellectual capabilities. The association believed that rather than teaching more and more content, it is more important to improve the effectiveness of teaching content that is essential for science literacy.

The AAAS (1990) considered science education to be "education in science, mathematics, and technology" (p. xiii). They believed that science education, therefore, should prepare students to "participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital" (p. xiii). This can be accomplished,

in part, through the application of technology. As noted by the AAAS, despite the fact that many problems facing humanity, both globally and locally, originate with technology, it is technology itself that furnishes us with the tools for coping with the problems and also for discovering new knowledge.

The *Science for All Americans* project (AAAS, 1990) identified several teaching strategies that are crucial to science, mathematics, and technology education. Among the approaches cited were engage students actively, use a team approach, provide abundant experience in using tools, and emphasize group learning. The *National Science Education Standards* (National Academy of Science [NAS], 1995) address the shortcomings of science education in the United States and incorporate these approaches in its recommendations. Specifically, the new standards call for pregraduation science teachers to learn to teach in an applied, constructivist manner.

Seeking Technology Educators' Opinions

Since the new Science Education Standards (NAS, 1995) mandate, science teachers are learning to teach with a hands-on approach, one infused with constructivist ideas. Furthermore, many professionals in technology education (Bredderman, 1987; Shamos, 1995; Welty, 1996) have long felt that the study of technology facilitates the learning process in all subjects, particularly mathematics and science. Therefore, I sought to determine the opinion of teacher educators as to (a) the role that technology teacher education should play in preparing new science teachers and (b) whether we will be doing a service or disservice to technology education programs by getting involved.

All 258 individuals listed as department chairs, heads, or coordinators in the *Industrial Teacher Education Directory* (1998-99) and all 66 members of the Mississippi Valley Technology Teacher Education Conference (MVTTEC), a total of 324 people, comprised the original population. Chairs were chosen using purposive sampling (Fraenkel & Wallen,

1996), based on the belief that these individuals are the opinion leaders in their respective departments.

Instrumentation

The *Technology Education's Role in the New National Science Standards Opinion Survey* was developed to measure the opinions of technology teacher educators as to whether or not technology teacher education programs should get involved in the pregraduation education of science teachers, and if so, the role that the programs should play. It consisted of three parts. The 25 statements in the first part (see Table 1) were taken directly from the National Science Standards (NAS, 1995) and were selected because of their relationship to the goals of technology education (International Technology Education Association [ITEA], 1996). Respondents were requested to circle either *yes* or *no* to indicate whether or not they felt preservice technology education courses should be used to assist in meeting the standard or goal expressed in the statement.

The second part of the questionnaire requested the respondents to rank the top three statements to which technology education can most contribute. The final part of the questionnaire solicited input, via open-ended questions, as to the specific role that technology teacher education should play in preparing new science teachers and whether or not a service or disservice would be done to technology teacher education programs by getting so involved.

Technology Teacher Educators' Views

The instrument and cover letter were mailed to the 324 subjects in late September 1999, and 80 usable instruments were returned, for a total return rate of 25.24% (80 out of 317). The return rate for members of the MVTTE Conference was 57.14% (36 of 63) compared to a return rate of only 17.05% (44 of 254) for department chairs. Of the 80 respondents, 45% ($n = 36$) were members of the MVTTE Conference, and 55% ($n = 44$) were chairs/heads/coordinators of departments with technology teacher education programs across the country.

The data from the first section were tabulated and analyzed using percentages of *yes* and *no* responses. Data from the second section (ranking of the top three statements) were tabulated with a value of 3 assigned to

the statements ranked first. Statements ranked second were assigned a value of 2, and those statements ranked third were assigned a value of 1. All other statements, therefore, received a value of 0. The values were then totaled to arrive at the final ranking of statements.

Two questions comprised the final section of the questionnaire. The first one, an open-ended question, asked about the specific role technology teacher education should play in preparing new science teachers. The second question asked if the respondent thought we would be doing a service or disservice to technology teacher education by getting involved. These responses were tabulated and analyzed using percentages for either *service* or *disservice*.

Ninety percent or more of the respondents indicated that the following five science standards (statements) should be addressed through preservice technology education courses:

- #4 Have the opportunity to engage in active learning that builds their knowledge, understanding, and ability (95% agreement, $n = 76$).
- #1 Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects (93.75% agreement, $n = 75$).
- #7 Have direct contact with phenomena, gather and interpret data using appropriate technology, and be involved in groups working on real, open-ended problems (93.75% agreement, $n = 75$).
- #6 Use a variety of technological tools, such as computerized databases and specialized laboratory tools (91.25%, $n = 73$).
- #20 Have a broad repertoire of instructional strategies that engage students in multiple ways (90% agreement, $n = 72$).

The following six standards (statements) received the *least* number of favorable (*yes*) responses:

- #11 Develop a deep understanding of accepted scientific ideas and the manner in which they were formulated (45% agreement, $n = 36$).
- #16 Be able to connect and integrate all pertinent aspects of science and science education (52.5% agreement, $n = 42$).
- #24 Be able to conduct research in their classrooms on science teaching and

Table 1. Science Standards Statements

Prospective science teachers should:

1. Be able to make conceptual connections within and across science disciplines, as well as to mathematics, technology, and other school subjects;
2. Be able to use scientific understanding and ability when dealing with personal and societal issues;
3. Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry;
4. Have the opportunity to engage in active learning that builds their knowledge, understanding and ability;
5. Engage in the collaborative aspects of scientific inquiry;
6. Use a variety of technological tools, such as computerized databases and specialized laboratory tools;
7. Have direct contact with phenomena, gather and interpret data using appropriate technology, and be involved in groups working on real, open-ended problems;
8. Have opportunities to develop understanding of how students with diverse interests, abilities, and experiences make sense of scientific ideas and what a teacher does to support and guide all students;
9. Be introduced to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge;
10. Be involved in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding;
11. Develop a deep understanding of accepted scientific ideas and the manner in which they were formulated;
12. Be able to address problems, issues, events, and topics that are important to science, the community, and teachers;
13. Have the opportunity to use scientific literature, media, and technology to broaden their knowledge beyond the scope of immediate inquiries;
14. Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching;
15. Have learning experiences in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriate contexts;
16. Be able to connect and integrate all pertinent aspects of science and science education;
17. Be able to integrate their knowledge of science content, curriculum, learning, teaching, and students;
18. Be able to tailor learning situations to the needs of individuals and groups;
19. Have a firm grounding in learning theory; understanding how learning occurs and is facilitated;
20. Have a broad repertoire of instructional strategies that engage students in multiple ways;
21. Have the ability to examine critically and select activities to use with their students to promote the understanding of science;
22. Develop an understanding of how students with different backgrounds, experiences, motivations, learning styles, abilities, and interests learn science;
23. Be able to collaborate with other teachers, teacher educators, teacher unions, scientists, administrators, policy makers, members of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each;
24. Be able to conduct research in their classrooms on science teaching and learning and be able to share their results with others;
25. Be able to articulate questions, pursue answers to those questions, interpret information gathered, propose applications, and fit the new learning into the larger picture of science teaching.

learning and be able to share their results with others (55% agreement, $n = 44$).

#10 Be involved in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding (57.5% agreement, $n = 46$).

#3 Understand the nature of scientific inquiry, its central role in science, and how to use the skills and processes of scientific inquiry (62.5% agreement, $n = 50$).

#17 Be able to integrate their knowledge of science content, curriculum, learning, teaching, and students (63.75% agreement, $n = 51$).

The final part of the instrument consisted of two questions. The first question was, "Specifically, what role should technology teacher education play in preparing new science teachers?" Phrases or terms such as collaboration, real-life experience, hands-on experiences, and application appeared in a majority of the responses.

The second question asked the respondents, "Will we be doing a service or disservice to technology education programs by getting involved?" Seventy-two percent of the MVTTE members ($n = 26$) believed that we will be doing a service, along with 70.4% ($n = 31$) of the department chairs/heads/coordinators, for a total of 71.25% ($n = 57$) of all the respondents. Also, 12.5% of the total respondents ($n = 10$) believed that we will be doing a disservice, and 16.25% ($n = 13$) had no opinion.

What Does It Mean?

The data collected from the respondents indicate substantial support (71.25% of those surveyed) for technology teacher educators to become involved in the preparation of new science teachers to meet the mandate of learning to teach in an applied, constructivist manner. Their views are that technology teacher education should be utilized in the preservice education of science teachers to give them instruction and/or experience in the following:

- Providing for *active learning* (Statement 4).
- Making conceptual connections across disciplines (Statement 1).

- Group problem solving using a variety of Technologies (Statement 7).
- The use of a variety of technological tools (Statement 6).
- Multiple teaching strategies (Statement 20).

These views are consistent with the widely held belief that technology education can and should be the course in the curriculum, at any level, where students are provided with opportunities to apply knowledge from various disciplines to solve problems (Lux, 1998). The *Technology for All Americans Project* (ITEA, 1996) included a discussion about how technology education can help develop a "richer sense of the relationships between technology and other school subjects . . . such as science and mathematics" (p. 40). Welty (1996) also described the roles that technology education can play in curricula at any level. He noted that the study of technology can be used to:

- teach concepts that are unique to technology;
- create contexts that make other aspects of the curriculum more meaningful to young people; and
- engage students in thought processes that promote the development of higher-order thinking skills. (p. 5)

Support is also implied for the Science-Technology-Society (STS) multidisciplinary curriculum initiative that "has become increasingly visible on college and university campuses during the past 20 years" (Gilliom, Helgeson, & Zuga, 1991, p. 233). As colleges and universities move toward implementing the STS multidisciplinary curriculum, the inclusion of one or more courses dealing with technology into the curriculum of science education majors will be commonplace.

The National Science Board (1983) emphasized that "the study of technological systems should be used as a basis for providing integrated and holistic learning" (p. 84). As far back as 1938, Dewey stated that "it is a sound educational principle that students should be introduced to scientific subject matter and be initiated into its facts and laws through acquaintance with everyday social applications" (p. 98). Johnson (1990) believed that "technology education can contribute to improving science and mathematics education" (p. 1), and that teachers who can "use technology as a curriculum integrator can add a sense of reality generally missing from current schooling" (p. 44).

Learning to teach in an applied,

constructivist manner, therefore, should not be restricted to prospective science teachers. All teachers, regardless of discipline, should be prepared to assist students in applying knowledge and using technology to solve problems. The National Science Board wrote in 1983 that “technology topics need to be integrated into the present curriculum. This includes science and mathematics classes, industrial arts, social studies and the language arts, and art and music” (p. 75). A required technology education course in the teacher education curriculum would provide all preservice teachers, regardless of discipline, with the necessary skills and abilities to implement application and problem-solving

activities for their students. As the Montgomery County Public Schools (1995) reported, “this combined ‘know-how’ and the ‘ability to do’ in carrying out technological work transforms technological understandings, communication skills, language arts skills, social and societal understandings, mathematical concepts, and scientific knowledge into reality” (p. 5).

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In the early 1990s, Johnson (1992a) stated that technology educators had shown little interest in cognitive science-based research which he observed was unfortunate because of the close alignment between many concepts in cognitive science and technology education. That may be less true today, but the disconnect between being aware of these concepts and/or terms and teaching students to be able to consciously use these constructs to enhance learning is still apparent. It also appears that there is very little research on these cognitive science theories within the context of technology teacher education or technical education in general.

This article explores technology teacher educators' perceptions about and use of the following cognitive science theories: schemata, mental and graphic visualization, reflection and debriefing, situated learning or cognition, cognitive apprenticeship and its component parts modeling, coaching and scaffolding, and metacognition. These theories are followed by a discussion of a survey of a selected group of teacher educators. The survey focused on three questions:

1. How important do technology education teacher educators believe each of the identified cognitive science concepts are for inclusion in the preparation of preservice technology education teachers?
2. To what level do preservice teachers learn about or develop skills in each of these cognitive science concepts in preservice technology education teachers programs?
3. To what extent are these cognitive science concepts modeled and integrated into classroom instruction for preservice teachers?

The Theories

Cognition has been defined as *coming to know*. It includes the internal mental processes of learning, perception, comprehension, thinking, memory, and attention and is grounded in an evolutionary shift in the psychology of learning from behaviorist to cognitive focus (West, Farmer, & Wolff, 1991). Cognitive science developed a social constructivist view of learning because it was learned that students actively incorporate social interaction and personal experience into the

process of transforming information to knowledge (Johnson, 1992a). After examination of accessible cognitive science literature, I found the literature highlighted the following learning theory-based concepts that seemed to relate directly or indirectly to experiential learning.

Metacognition.

Metacognition collectively consists of the becoming aware of personally preferred cognitive strategies as well as acquiring, employing, and monitoring new strategies for learning (Johnson, 1992b; West et al., 1991). Also called strategic thinking, metacognition involves planning, regulating, and evaluating thinking activities. It includes such strategies as monitoring, questioning, summarizing, predicting, generating, and evaluating alternatives. Knowledge is obtained through identification of relationships and connections. Experiential learning is necessarily personal and idiosyncratic (Burnard, 1988). Metacognitive strategies are useful to the learner as he or she attempts to translate personal experience to transferable learning.

Schema Theory.

People engage in information simplification to effectively manage their information processing requirements. Schema theory suggests that schemata are unconscious mental structures or models that underlie and control the simplifying process that is essential to human learning, skill acquisition, and problem solving (Johnson, 1992a; Phillips & Lord, 1982; Satchwell, 1996; West et al., 1991). It has been suggested that schemata:

- reflect the individual's basic ideas about reality and relative importance;
- provide a framework for memory within which decisions can be made, operations performed, and new information retained;
- define understanding of how the world is organized and new information fits with previously acquired knowledge;
- provide structure to ambiguous or incomplete information;
- allow the individual to fill in missing data and edit information as it is retrieved from memory; and
- guide the information retrieval process (Brewer & Nakamura, 1984; Kelley, 1972).

Table 1. Metacognition Related Responses

<i>n</i> = 29	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of metacognition in technology teacher education	11 - 38%	16 - 55%	2 - 7%
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept	Not Learned
Level of learning about metacognition by preservice technology education teachers	7 - 23%	17 - 54%	7 - 23%
<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is metacognition modeled or integrated by faculty into instruction	3 - 10%	19 - 61%	9 - 29%

Schemata are developed and information is encoded and organized based upon the individual's first-hand experience as the individual retains and processes implicit and explicit teachings about the causal nature of the world, thus enabling persons to perform with limited information (Kelley, 1972). Preconceived causal beliefs influence not only interpretation of events and information, but also what information will be sought and how it will be used (Kelley & Michela, 1980; Wyer, 1981). These complex schema-based images exist in memory as perceptions of particular individuals, events, etc., or as prototypic perceptions (Wyer, 1981).

It is believed that people possess schemata of connected facts, skills, and strategies that help the individual explain and perform efficiently within his or her world. New information and/or experiences are interpreted through mental analysis based on comparison against existing relevant schemata. These schemata or mental models become the basis for interpretation of what actions are appropriate and which information may be assumed as well as learning and recall (Satchwell, 1996; West et al., 1991). Acknowledging preexisting schema changes the role of the technology teacher who wants to help students learn effectively through personal experience. Students must be encouraged to

actively engage in activities that focus on examining causal relationships and comparing these relationships against their preexisting notions about technology and the world.

Visualization and Graphic Organizers

The term *chunking* has been used to describe a broad array of organizing and simplifying strategies that aid in learning and analysis (West et al., 1991). Memory organization tools and aids to supplement limited working memory capacity such as those included under the umbrella of chunking have been shown to enable experts to recall enhanced volumes of information when needed to solve problems and transfer knowledge to new situations (Johnson, 1992a; Johnson & Thomas, 1992). Chunking includes use of both graphic organizers and visual imagery.

Graphic organizers such as concept mapping and functional flow diagrams could be of particular interest to technology educators. Concept maps graphically simplify the display of concepts and the relationships between those concepts as a means of communicating, comprehending, and analyzing relationships of a physical system or body of knowledge. They have been shown to effectively act as mnemonic devices to help learners remember as well as aiding in analysis and understanding, troubleshooting, and problem solving. Providing or teaching

Table 2. Schema Theory Related Findings

<i>n</i> = 29	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of schema theory in technology teacher education	7 - 24%	16 - 55%	6 - 21%
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept	Not Learned
Level of learning about metacognition by preservice technology education teachers	4 - 13%	18 - 58%	9 - 29%
<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is schema theory modeled or integrated by faculty into instruction	4 - 13%	13 - 42%	14 - 45%

learners to create simple conceptual diagrams helps students gain conceptual, holistic understanding more quickly (Johnson, 1992a; Johnson & Thomas, 1992; Satchwell, 1996; West et al., 1991). Use of simplified conceptual diagrams may improve overall system understanding, enhance ability to understand function and behavior of systems, enhance understanding of causal relationships, and improve learner ability to reconstruct conceptual models (deKleer & Brown, 1981; Satchwell, 1996), or visual, coherent pictures that are less easily forgotten.

Visual imagery has long been used to teach drafting concepts as students were challenged to visualize objects mentally cultivating the ability to rotate and section parts and assemblies as well as providing essential skills in invention and innovation based on design activities. More recently, visual practice has also been proposed as a method to provide low cost practice and enhancement of tasks requiring fine motor skills, high levels of eye-hand coordination, and with significant cognitive elements. This cognitive technique essentially consists of repeatedly thinking through a problem or process in a highly structured and disciplined manner (Whetstone, 1995).

Reflection.

Reflection has been described as “those intellectual and affective activities in which

individuals engage to explore their experiences in order to lead to new understandings and appreciations” (Boud, Keough, & Walker, 1985, p. 18). Few people can convert personal experience to transferable learning, principles, or models through the experience alone. However, the probability of the student making that transition is enhanced if the student is encouraged to focus, share, and reflect on the meaning of the experience, the connections between the experience and past experiences, theories, and/or generalizable models. Opportunities to reflect on and observe the meaning of experiences, then integrating those reflections and critical observations into personal theories, enhance the probability of transfer of learning to new contexts and situations (Burnard, 1988; Kolb, 1984).

Experiential learning has been described as having six distinct phases: planning, introduction, activity, debriefing, summary, and evaluation. In this model, the reflection or debriefing phase involves sharing and discussing the experience: its details, order, and meaning. This is the opportunity for participants to begin to make generalizable connections to prior learning and experiences (Walter & Marks, 1981).

Reflection has been defined as the mental process of looking back over the completed experience and performance to assess and

Table 3. Visualization and Concept Mapping Related Responses

<i>n</i> = 30	Essential or Very Important	Important or Somewhat Important	Not Important	<i>n</i> = 30	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of visualization in technology teacher education	24 - 80%	6 - 20%	0	Importance of knowledge of concept maps in technology teacher education	14 - 47%	16 - 53%	0
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend or Are Aware of Concept	Not Learned	<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept Maps	Not Learned
Level of learning about visualization by preservice technology education teachers	18 - 58%	12 - 39%	1 - 3%	Level of learning about concept maps by preservice technology education teachers	12 - 39%	18 - 58%	1 - 3%
<i>n</i> = 31	Routinely	Occasionally	Not at All	<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is visualization modeled or integrated by faculty into instruction	19 - 61%	11 - 35%	1 - 3%	To what extent are concept maps modeled or integrated by faculty into instruction	10 - 32%	16 - 52%	5 - 16%

analyze, to make connections to convert experience into learning (Collins, 1989). The need for reflection too often becomes apparent when students participate in classroom-based instructional experiences. Many students seem to follow the recommended procedures but fail to grasp the significance of the event, the connections between their recent experience and relevant previously acquired knowledge (West et al., 1991). Reflection and articulation of ideas and thought as instructional practices enhance the ability to actively use and apply knowledge in other contexts (Schell & Black, 1997). It has been these reflective or debriefing and summary phases that the author has observed are often overlooked when experiential learning activities have been observed in technology education laboratories.

Situated Cognition/Learning

Knowledge learned in context contains information about the conditions and constraints of its subsequent use. The context of learning impacts the learner's later ability to recall the knowledge as well as understanding of the factors and conditions that are likely to accompany application of the learning and the ability to transfer it to new contexts (Johnson, 1992a; Johnson, 1995; West et al., 1991).

It is believed that situating learners in social contexts where understanding is valued and socially acquired enhances the probability of transfer and application of that knowledge to contexts in the realm of practice outside the classroom (Schell & Black, 1997; Stern, 1998).

Situated learning allows students to construct meaning from their experiences through doing. Students do not rely on segmented instruction structured and presented by instructors. The learning experience is problem or dilemma driven, not dictated by content structure. Instructional experiences are those that will be encountered at home, in the community, and in the workplace (Stern, 1998). The process of situated learning centers around three basic elements: (a) discovery and application of content; (b) the context, which defines likely future use and transfer; and (c) the community of practice, which joins analysis, reflection, and shared language that help achieve shared understanding (Stern, 1998).

The idea that learning should be grounded in reality and practical application is not new (Dewey, 1938, 1956; Whitehead, 1929). It has long been believed that the context in which something is learned influences later use of that knowledge. Transfer of learning to useful contexts outside the classroom is an essential goal of technology education.

Cognitive Apprenticeship, Modeling Cognitive Processes, Coaching and Scaffolding

Cognitive apprenticeship is believed to provide structure to knowledge through creation of mental models and enhanced development of contextualized problem-solving processes. The cognitive apprenticeship is a metaphor for the modifying of classroom instructional techniques to incorporate aspects of traditional apprenticeship training approaches. In traditional

Table 4. Reflection Related Responses.

<i>n</i> = 29	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of reflection in technology teacher education	14 - 48%	15 - 52%	0
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept	Not Learned
Level of learning about reflection by preservice technology education teachers	11 - 35%	19 - 61%	1 - 3%
<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is reflection modeled or integrated by faculty into instruction	11 - 35%	18 - 58%	2 - 6%

apprenticeship models (a) work and doing are fundamental; (b) skills are developed beginning with easier, low-risk events and progressing to the more challenging; (c) the ability to know and do are inseparable; (d) standards of performance are established by the community of practice; and (e) teaching is a support activity with guided practice and performance taking center stage (Berryman, 1999).

In the cognitive apprentice model four essential features prevail: application of content with cognitive strategies imbedded, experiential methods, sequencing from the simple to the diverse and complex challenge, and the sociology of the community of practice. The focus is on individual and group problem solving situated in contexts that recreate real-world contexts using the instructional concepts of modeling, coaching, and scaffolding or fading while providing increasingly complex opportunities for learning (Berryman, 1999; Brown, Collins, & Duguid, 1989; Cash, Behrmann, Stadt, & Daniels, 1996; Collins, Brown, & Newman, 1989; West et al., 1991).

Many of the skills people learn throughout life are initially acquired and enhanced through imitation. Modeling involves conscious verbalization by the instructor of those internal cognitive strategies used by experts when solving complex problems and analyzing connections to existing knowledge. Cognitive

modeling benefits students by making visible how experts approach problems by integrating skills and knowledge (Collins, 1989). For cognitive strategies to be acquired this way through modeling and imitation, the instructor must not only exhibit the outward manifestations of learning, problem solving, and interacting but must also make explicit the mental thought processes used. In this way cognitive strategies used by experts can be demonstrated, emphasized, and reinforced. This emphasis and reinforcement increases the probability of the strategies continued use (West et al., 1991).

Coaching involves providing “students a different perspective from which to understand their own performance” (Collins, 1989, p. 3). Traditional coaching techniques include demonstrating skills, offering hints, and providing formative feedback and reminders (Berryman, 1999; Brown et al., 1989). The effective coach provides only as much help as needed at critical times and focused on individual difficulties (Collins, 1989).

The term *scaffolding* refers to management of type and intensity of instructional guidance provided by the instructor/mentor that is designed to aid the student in increasing competence and expertise through solution of increasingly ill-defined and complex problem-solving experiences. The novice is encouraged

Table 5. Situated Cognition Theory Related Responses

<i>n</i> = 31	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of situated cognition in technology teacher education	23 - 74%	8 - 26%	0
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept	Not Learned
Level of learning about situated cognition by preservice technology education teachers	14 - 45%	11 - 35%	6 - 20%
<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is situated cognition modeled or integrated by faculty into instruction	15 - 48%	10 - 32%	6 - 20%

to practice problem-solving and complex skills under the direct supervision of the expert. As the novice develops expertise, supervision and oversight are gradually lessened, culminating in fading (a gradual pulling back by the teacher) as the student assumes more control over the learning process until finally supervision is removed (Berryman, 1999; Brown et al., 1989; Stern, 1998; West et al., 1991).

An essential aspect of learning under the cognitive apprenticeship model is that the student explores the shared culture and language of the community of practice, reflecting upon and evaluating newly acquired skills and solutions in the context of community practice (Brown et al., 1989). In this way the cognitive processes of the novice can begin to emulate those of the expert.

Views of the Constructs

Sixty-five programs that reported three or more technology education undergraduates or three or more teachers certified in technology education in the 1998-1999 CTTE/NAITTE *Industrial Teacher Education Directory* (Bell, 1998-1999) were contacted. Thirty-one instruments were completed and returned for a 50% response rate (after removing programs from the list that no longer offered technology teacher education). Only simple descriptive statistics were used in analysis of data.

1. *Metacognition.* There was strong support for the importance of metacognition in technology teacher education. Thirty-eight percent (11) of the respondents described metacognition as essential or very important, and an additional 55% (16) indicated that it is important or at least somewhat important. Surprisingly, given this level of perceived importance, 23% (7) of the programs said that the concept of metacognition was not taught to students in their programs. Further, 29% (9) indicated that faculty do not model or integrate metacognition into their instruction, and an additional 61% (19) indicated that this concept is only occasionally modeled or integrated into instruction.
2. *Schema Theory.* Twenty-four percent (7) of the respondents identified knowledge of schema theory as essential or very important and 55% (16) selected important or somewhat important in technology teacher education. This seems to indicate a strong (79%) acceptance of the importance of understanding this theory. This is also supported by the 18 (58%) programs which indicated that their students comprehend or are aware of schema theory and the additional programs where students practice or become proficient in use of schema theory. A question is raised by the responses that

Table 6. Cognitive Apprenticeship and Cognitive Modeling Related Responses

<i>n</i> = 29	Essential or Very Important	Important or Somewhat Important	Not Important	<i>n</i> = 31	Essential or Very Important	Important or Somewhat Important	Not Important
Importance of knowledge of cognitive apprenticeship in technology teacher education	12 - 41%	15 - 52%	2 - 7%	Importance of knowledge of cognitive modeling in technology teacher education	18 - 58%	11 - 35%	2 - 6%
<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend or Are Aware of Concept	Not Learned	<i>n</i> = 31	Proficient or Have Practiced Application Use	Recognize, Comprehend, or Are Aware of Concept Maps	Not Learned
Level of learning about cognitive apprenticeship by preservice technology education teachers	11 - 35%	11 - 35%	9 - 29%	Level of learning about cognitive modeling by preservice technology education teachers	9 - 29%	15 - 48%	7 - 23%
<i>n</i> = 30	Routinely	Occasionally	Not at All	<i>n</i> = 31	Routinely	Occasionally	Not at All
To what extent is cognitive apprenticeship modeled or integrated by faculty into instruction	10 - 33%	11 - 37%	9 - 30%	To what extent is cognitive modeling modeled or integrated by faculty into instruction	12 - 39%	12 - 39%	7 - 22%

indicated that 87% (27) of these technology teacher education programs have faculty that model and/or integrate use of schema theory into instruction only occasionally or not at all. Teacher educators in our field are very familiar with the disparity that often exists between a student’s knowledge and his or her ability to apply that knowledge. If you accept the axiom in instruction that teachers tend to teach as they were taught, this last finding makes one wonder about the likelihood that most new technology education teachers from these programs will incorporate this theory into their personal practice.

3. *Chunking.* Two questions focused on chunking related techniques such as visualization and graphic organizers, specifically concept maps. Support by teacher educators for the importance of knowledge of visualization was very strong with 80% (24) of the respondents describing it as essential or very important and the remaining 20% (6) describing it as important or somewhat important. This high level of perceived importance apparently is also reflected in practice as instruction is delivered to preservice teachers.
4. *Visualization and Concept Mapping.* Fifty-eight percent (18) of the students are reported to practice or become proficient in the use of visualization. This is further (routinely or occasionally) modeled or integrated into preservice teacher instruction by faculty in 96% (30) of the

31 programs reporting. While support for knowing about concept mapping was also strong, it was surprisingly less strong than that expressed for visualization. One respondent indicated that knowledge of concept mapping was not important, and over one half (16 of 30) described it as important or only somewhat important. Similarly, 58% (18) of the programs reported that students learn about concept mapping at only the comprehension, recognition, or awareness levels. Further use of concept maps is modeled or integrated into instruction by teacher education faculty only occasionally (52%) or not at all (16%) in 68% of reporting programs. This last finding was puzzling, considering the apparent support for knowing about concept maps and the usefulness of such tools in understanding, learning about, and troubleshooting technological systems. It appears that students come out of some technology education programs with knowledge of graphic organizers but little experience in using these useful tools.

5. *Reflection.* Technology teacher educators acknowledged the importance of knowing about reflection as a tool to aid in transforming experience into learning. Forty-eight percent of the respondents described this concept as essential or very important in technology teacher education. An additional 52% (15) classed it as important or somewhat important. Levels of learning about reflection by

preservice teachers was reported similarly with 35% reporting that students practice or become proficient in application of reflection. Sixty-one percent (19) indicated that students achieve recognition, comprehension, or awareness levels of learning about reflection. The degree to which reflection was reportedly modeled or integrated into faculty instruction closely mirrored the levels of learning with this cognitive skill routinely modeled or integrated in 35% (11) of the programs and occasionally modeled or integrated in 58% (18).

6. *Situated Cognition or Learning.* This concept was strongly supported as 74% (23) selected essential or very important to describe its importance in technology teacher education. The remaining respondents thought it important or at least somewhat important. Once again, this overwhelming support for the importance of the concept does not necessarily translate into classroom instruction or experiences. Almost 20% (6) of the program representatives said that students do not learn about situated cognition in their teacher preparation. To further support this discrepancy, the same 20% said faculty did not model or integrate situated cognition into their instruction and an additional 32% included it only occasionally.
7. *Cognitive Apprenticeship and Its Components.* As before, there is strong support for the importance of including this into technology teacher education. Forty-one percent (12) identified it as essential or very important and an additional 52% (15) classified this technique as important or at least somewhat important to our field. Again, support is not necessarily followed by action in teacher preparation. Twenty-nine percent (9) indicated that students in their programs do not learn about cognitive apprenticeship. Further, the same number indicated that faculty do not model or integrate cognitive apprenticeship into instruction and an additional 37% (11) indicated that it was included only occasionally.

The trend is mirrored in the data about cognitive modeling. Fifty-eight percent (18) of the program representatives indicated that knowledge of cognitive modeling as a teaching

technique for technology education teachers is either essential or very important and an additional 36% (11) classified the technique as either important or at least somewhat important. Their perceptions of importance did not translate into student learning or instruction. Students in 23% (7) of the programs do not learn about cognitive modeling as a teaching technique. In 23% of the reporting programs, cognitive modeling was neither modeled nor integrated into faculty instruction, and in an additional 39% (12) this technique was only modeled or integrated occasionally by faculty.

Overwhelming support exists for coaching as an instructional technique in technology teacher education. Fifty-eight percent (18) described knowledge of this concept as essential or very important and the remaining 42% described it as important or at least somewhat important to know about.

Scaffolding was afforded far less importance than coaching. Twenty-nine percent (9) of the respondents described scaffolding as essential or very important, but 19% (6) considered knowledge of this construct not important. This same disparity continued as participating teacher educators indicated that students in 42% of their programs do not learn about scaffolding as an instructional technique and 94% noted that faculty in their programs model or integrate scaffolding into instruction only occasionally (55%) or not at all (39%).

The Questions in Light of the Survey Results

What is the relationship between the experiential learning approach of technology education and the findings of cognitive science?

It has frequently been proposed that a technology education program should prepare a technologically literate person with "the ability to use, manage and understand technology" (ITEA, 1996, p. 6). Similarly, Johnson (1992a) observed that effective technology education programs provide students with knowledge to understand technology, technological skills, and opportunities to using their knowledge and skills to solve technological problems. The universal foundations proposed for structuring and organizing the study of technology in technology education programs are processes, knowledge, and contexts (ITEA, 1996). This same focus on acquiring technological knowledge, skills/

processes, and the ability to transfer skills/knowledge to new contexts would seem to be important to structuring instructional delivery in technology teacher education.

The primary focus of the cognitive science constructs discussed in this article are increasing the efficiency of learners in converting information and experience into learning, enhancing retention of learning, enhancing transfer of knowledge and skills to new contexts and situations, and helping students take greater responsibility for their own learning. These goals would seem to be closely related. Johnson (1992a) identified several areas in cognitive science that should be of particular interest to technology educators:

- Mental models, graphic organizers, and other learning aids designed to help students link prerequisite knowledge or schema to new knowledge and experiences.
- Metacognition.
- Situated cognition, and other aspects of cognitive apprenticeship, particularly cognitive modeling.

Each of these cognitive science constructs or techniques enhances learning or transfer of learning to new applications or contexts. The responses to my survey suggest that many technology teacher educators support Johnson's suggestion that many cognitive science theories and related instructional techniques are very closely aligned with technology education and its traditional emphasis on experiential learning.

To what extent are the theories of cognitive science embraced, integrated, and taught by technology teacher education programs?

One respondent to this survey observed that there is an important distinction between knowing about cognitive science concepts and deliberately implementing cognitive science theory. This aptly describes the situation reported in the survey responses. While 48% to 80% of the responding educators described the top five constructs as essential or very important, only 35% to 58% indicated that technology teacher education students learn about these concepts to the extent that they practice or become proficient in their use. Further, these concepts were routinely integrated into or modeled during faculty instruction in 35% to 61% of the programs. This relationship for the five least favored cognitive science constructs (24% to 47% identifying concepts as essential or very important) and levels of learning (13% to 39% providing students with

opportunities to practice or become proficient in use of concepts). Instances of integration and/or modeling show even larger relative differences with 6% to 33% of the programs indicating that these concepts were routinely integrated into or modeled during faculty instruction. Clearly there is a difference in levels of knowing and doing in teacher education programs, just as there are differences in perceptions of importance and the frequency that faculty model or integrate concepts into their own instruction.

To what extent should the theories of cognitive science be embraced, integrated, and taught by technology teacher education programs?

I found that many teacher educators rank many of these cognitive science constructs as essential or very important in training technology education teachers who are preparing to teach the hands-on/minds-on approach to technology education. Well over one half of all respondents rated visualization, situated cognition, coaching, and modeling cognitive processes as essential or very important.

The participants' perceptions of preparation of technology teachers in rank order of importance from most to least important resulted in the following:

1. Visualization
2. Situated cognition
3. Coaching
4. Cognitive modeling
5. Reflection and debriefing
6. Concept mapping
7. Cognitive apprenticeship
8. Metacognition
9. Scaffolding
10. Schema theory

Note that several of the constructs Johnson (1992a) highlighted as of particular interest to technology education, specifically mental models, visual or graphic organizers, schemata, and metacognition, were ranked among the lowest in importance by these teacher educators.

It is regrettable that little change in the conditions that Johnson had reported in 1992 were found. Now, as then, the concepts and techniques that have emerged from cognitive science research appear to have great potential for enhancing the study of technology at all levels and yet the number of authors studying and writing about these ideas in technology education and/or other related technical education contexts during the last decade can still be easily counted on your fingers.

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The Crucial Role of Local Number Portability in Today's Telecommunications Industry

Tim Obermier

Thanks to the groundbreaking discovery of the telegraph by Samuel Morse in 1837 and the telephone by Alexander Graham Bell in 1876, today we have access to telecommunication services and devices of all types. From innovations as unique as wireless Internet access on cellular telephones to the standard plain old telephone in our homes, living without telecommunication is unimaginable. People often look back in wonder at the development of major historical technological inventions; the telephone is no exception. The story of how Alexander Graham Bell invented the telephone has been immortalized through several movie and theatre productions, television documentaries, and historical writings. These historical accounts often favor the drama of the invention and discovery process, but often reveal little about the events which surrounded its societal implementation. Analysis of early telephone technology deployment reveals important lessons about competitive market forces and regulatory issues that can be applied to two important emerging issues: local telephone number portability and depletion of telephone numbers. Local number portability is the ability of customers to retain their telephone number when they change telephone service providers. Regulations heavily influence the success, failure, and creation of any new technologies in telecommunications.

Historical analysis of competition in the telecommunications industry, since the invention of the telephone, provides insight into three main issues. First, history will prove anti-competitive regulatory control is detrimental to technological innovation in the telecommunications industry. Second, local number portability could save the telephone numbering system from

eventual depletion. Third, and most important, why local number portability is essential to competition for local telephone service. A review of how local number portability is envisioned will demonstrate how this new concept will bring numerous benefits to the consumer in the new competitive telecommunications industry.

Historical Viewpoint: Competition in Telecommunications

According to Rowe (1999), patents issued to Alexander Graham Bell for the invention of the telephone in 1876 expired in the early 1890s, allowing several independent telephone companies to begin competition with the quickly growing Bell Telephone Company. Within six years of the expiration of Bell's patents, over 6,000 independent telephone companies competed with one another (Todd, 1999). Consequently, many telephone companies operated in the same city. However, problems arose for the fledgling telephone industry as competing companies refused to interconnect their systems. Without interconnection, individuals served by different telephone companies could not call one another. By not connecting competing systems, some companies were able to hold advantage over others and attract more customers. Once the competition could no longer survive, they were bought out, typically by the Bell Telephone Company. This business strategy created an obvious flaw in the deployment of telephone technology, the inability of the customer to have ubiquitous telephone service.

Absence of regulatory oversight allowed the Bell Telephone Company to rapidly expand as a result of buying other smaller telephone companies. Shaw (1998) observed that rapid growth

and assertive posturing of Bell's company served as a motivator for the federal government to establish regulatory control over the telecommunications industry. In 1913, the competitive tactics of Bell Telephone, renamed AT&T on December 31, 1899 (Todd, 1999), caused the U.S. Justice Department to invoke the Sherman Antitrust Act. According to Lynch (1996), the 1913 Kingsbury Commitment was an agreement between AT&T and the Justice Department that temporarily slowed AT&T's acquisitions of independent telephone companies. More important, Rowe (1999) indicated that the agreement recognized the importance of a common telecommunications infrastructure by requiring inter-connection between AT&T and the telephone companies that had not yet been purchased by AT&T, thus providing universal nationwide telephone service.

With such a large number of people being added to the telephone network, automatic switching mechanisms eventually had to be developed to make the connections from one party to another. Telecommunications technology rapidly advanced. Long distance services were deployed and tremendous improvements were made to deliver local telephone services. However, competition soon ended.

Competition Ends and Monopolies Begin

Cole (2000) reported that regulatory action by the federal government in 1921 formally recognized legitimate monopolies of telecommunication carriers by exempting them from the Sherman Antitrust Act. This regulatory action effectively ended competition in the telephone industry for several decades. The concept of the telecommunications

common carrier was firmly established. Common carriers are heavily regulated industries that by law are allowed exclusive rights to be the sole provider of services in a given geographic region. In return, companies are guaranteed a specific monetary return based on their infrastructure investment and cost of operation. Government agencies determine the rate of return for these monopolies to protect consumers.

With regulatory oversight, the technology of the telephone network continued to develop across the nation. However, two problems emerged: lack of competition and vertical integration of the industry. First, AT&T operated with a guaranteed rate-of-return and no competition; the motivation for AT&T to develop new technologies for the consumer did not exist. Early technological developments that could have benefited consumers were discouraged by AT&T and the Federal Communication Commission (FCC). The FCC was created in 1934 to regulate the fledgling telecommunications industry. According to Knauer, Tollin, Zachem, and Pastor (1998) in 1954, AT&T convinced the FCC to deny an early version of the answering machine. The FCC also denied a small plastic cup called the Hush-A-Phone that attached to the telephone mouthpiece to allow for more privacy during conversations. The concern at the time was that devices developed by companies other than AT&T could be harmful to the telephone network. This theory served as a barrier to the development of new services for customers for several years.

Although competition kept technological development for the end-user from advancing, "switching technology" continued to evolve because of the vast numbers of customers being added to the telephone network. According to Lynch (1996), several new network-enhancing technologies were developed during the monopoly of AT&T. Bell Laboratories, the research and development division of AT&T, was busy inventing the coaxial cable, microwave radio transmission, laser

technologies, and the transistor which led to electronic switching and tone dialing.

The motivation for improving technology of the network (rather than the technology and services for the consumer) was profit based. With better switching and more capacity for additional telephone calls, telephone companies could make more money. Wenders (1987) believes the rapid technological change, which has permeated the telecommunications industry, has focused primarily upon economies of scale for telephone companies. Little change has occurred in the actual delivery of services to the customer.

A second problem emerged as AT&T found a way to inflate its rate of return beyond what the government allowed. AT&T owned Western Electric, the company that produced the infrastructure for telephone systems. The price of the equipment was purposely overly inflated, and therefore the rate-of-return determined by the government was also inflated (Peck, 1988). This meant higher prices for the consumer. Thus began the decades-long process of de-regulating the telecommunications industry.

The Era of De-Regulation

Although the telephone network was heavily mired in regulation, preventing competition for several decades, other subindustries within telecommunications were allowed to develop in a competitive environment or were de-regulated through court action. Knauer et al. (1998) revealed that MCI had to sue to gain entry into the long distance market once monopolized by AT&T. MCI's successful legal efforts and the famous breakup of AT&T's Bell Telephone system in 1983 created the competitive industry of long distance. AT&T, in an agreement with federal regulators, was required to divest their local telephone companies, known as Bell Operating Companies. This resulted in AT&T becoming a competitive player in the long distance market (Cole, 2000). For

several years after 1983, long distance services continued to be dominated by AT&T with little competition. Accessing long distance lines for AT&T was accomplished by dialing the digit one. Until switching equipment could be changed so that dialing one provided access to the long distance company of choice, AT&T held competitive advantage. Bell Operating Companies, divested from AT&T, were limited by regulation to provide only local telephone service. They were not allowed into the lucrative long distance market. The long distance market has become increasingly competitive ever since 1983, and consumers are now provided a choice of companies, choice of long distance packages, and increased savings on long distance charges.

Kuruppillai, Dontamsetti, and Cosentino (1997) indicated that the FCC chose to favor a competitive approach in the awarding of the first cellular licenses. Licenses for frequency spectrum were granted in a duopoly format to create competition between two cellular carriers in each market. The resulting competition, and reduction in regulatory oversight, has been the rapid technological development of cellular telephones with more features to serve an increasingly mobile community. An example of new technologies in wireless is the personal communications system (PCS). PCS is a new technology that is similar to the cellular telephone in concept but operates in digital rather than analog format. PCS telephones are cheaper, more efficient, and safer to operate than analog cellular. Paging is another competitive industry with new features developing rapidly. Most recently we have seen the deployment of worldwide satellite telephones in competition with cellular telephones. Wireless services experience a high level of competition with rapidly advancing technology and increased services for the consumer. Individuals can now surf the Internet, obtain stock quotes, and receive faxes over their cellular telephones. All this would have been impossible without competition.

The most personally important

element of de-regulation is that consumers now own their own telecommunications devices; this is referred to as "customer premise equipment." According to Newton (1998), customer premise equipment is any telecommunications device owned by the consumer that is attached to the telephone network, including items such as telephones, modems, fax machines, and answering machines. Historically, telephone companies justified the renting of the telephone instrument, by saying that the telephone network might suffer harm from any equipment that did not meet its specifications. As a result, everyone had the same standard rotary dial telephone for years. Customer premise equipment was fully de-regulated in 1983 as a part of the breakup of AT&T. As the production and sale of these consumer devices emerged into a competitive market, many technological innovations began to occur. An entire industry sprang up overnight competing to develop answering machines, telephones, modems, and fax machines. The de-regulation of customer premise equipment is probably the most significant catalyst for the emergence of telecommunications as a competitive industry.

In its infancy, the telecommunications industry was highly competitive. At first, competitive pressure by AT&T created a monopoly that was later affirmed by Congress. Once society realized the benefits of a competitive telecommunications system, it was approximately 50 years before the final segments of the telecommunications industry was de-regulated. Long distance, cellular telephony, and customer premise equipment are all examples of competitive components of the telecommunications industry. They have become competitive through court action or regulatory decisions by the FCC. These competitive segments of the telecommunications industry have brought reduced costs and increased diversity in services to the consumer. However, new concerns have emerged.

Competition Brings Problems

Unfortunately, the technologies and services that developed in a competitive market are beginning to have a negative impact upon the telephone network. The implementation of pagers, fax machines, cellular telephones, personal communication systems, and computer modems are placing tremendous pressure upon the North American telephone numbering system. Each individual communication device requires a unique identification number (i.e., a telephone number) to be recognizable on a telephone network. As a result, telephone numbers are being consumed at an alarming rate. In response to the problem, the FCC has opened an inquiry to determine how telecommunications companies can more effectively utilize telephone numbers. The FCC Common Carrier Bureau (1999) indicated there are 215 area codes today as opposed to only 119 in 1991. Of the 215 area codes, 70 are soon to have all their telephone numbers exhausted. Once the available combinations of telephone numbers in an area code are exhausted, a new area code has to be created. This creates undue hardship on the individuals and businesses in the affected area. The bureau further estimated that all area codes will be consumed in 10 to 15 years if nothing is done to alleviate the impending number plan failure. One potential answer to saving the numbering system is to add an 11th digit to the current 10-digit telephone number. This move would cost telephone companies, and ultimately their customers, more than 150 billion dollars and take at least 10 years to complete. Adding an 11th digit to the telephone number would require additional regulatory oversight. Implementation of local number portability may provide a better solution through competition.

Local Number Portability

On February 8, 1996, President Clinton signed the Telecommunications Act of 1996 into law. The act is based upon the concept that all sectors of the

telecommunications industry should be open to competition. This act removes all the regulatory barriers that once existed. One of the most important sections of the act, according to Gable (1999), was the creation of competition in the heavily regulated local telephone sector. The act mandates the implementation of local number portability to facilitate competition in the local sector.

The Telecommunications Act of 1996 defined number portability as "the ability of users of telecommunications services to retain, at the same location, existing telecommunications numbers without impairment of quality, reliability, or convenience when switching from one telecommunications carrier to another" (FCC, 1996, paragraph 7). According to the Midwest Region Local Number Portability Administration Center (n.d.), there are three different types of number portability. (1) Service provider portability allows consumers to retain their telephone number while changing to a different service provider. This could include changing from a wireline to a wireless service provider. (2) Location or geographic portability lets consumers change from one geographic area to another and retain their telephone number. (3) Service portability enables people to change from Integrated Services Digital Network (ISDN) to Asymmetrical Digital Subscriber Line (ADSL) or basic telephone service and still retain their telephone number. ISDN and ADSL are types of services requiring specialized communications equipment, which dramatically speed up Internet connections to the home or business. Currently, the only form of local number portability required of telecommunications service providers is service provider portability (FCC, Common Carrier Bureau, Competitive Pricing Division, 1999). At this time, wireless service providers are excluded from service provider portability, but eventually the local number portability regulatory mandates will extend to the wireless industry.

To create competition among once monopolistic local telephone companies and enhance competition in other telecommunication markets, consumers need to be able to retain their telephone number as they change service providers. As reported by the FCC, studies conducted by several telephone companies reveal that consumers have little interest in changing their service providers if they have to change telephone numbers. "Based on a nationwide Gallup survey, 83 percent of business customers and 80 percent of residential customers would be unlikely to change local service providers if they had to change their telephone numbers" (FCC, 1996, paragraph 29). Gable (1999) indicated that the "principle road-block" to competition among local telephone service providers is the issue of "the ability of a customer to retain his telephone number after changing local service providers" (p. 15). The primary issue is cost and identity. Individuals who have had the same telephone number for years lose a certain identity when they are required to change their number. For businesses, this can be staggering. Imagine changing a number in every location where a business's number appears; the costs can be quite high. Advertising on billboards, signs on vehicles, yellow page advertisements, newspaper ads, and new business stationery all add up to major costs and headaches.

The Technology of Local Number Portability

To make local number portability functional, restructuring the way calls are routed must take place. Prior to local number portability, telephone calls were transmitted across the network on the basis of a 10-digit telephone number. Telephone numbers contain an addressing scheme with a defined format. The first three sets of digits contain the area code, a broad geographic area sometimes encompassing several local telephone companies. The next three digits contain the exchange code, which is the number that uniquely

identifies a specific central office of a telephone company. A telephone company may own several central offices that each serve a specific geographic area. The remaining four digits is the subscriber code, which identifies the specific customer served by a local telephone company. If a person dials long distance an 11th digit is added to the beginning of the sequence. Dialing the number '1' in the United States indicates a long distance call, but the number '1' is actually a country access code identifying the call as a U.S. call. The access code also indicates that a long distance carrier of the customer's choice will be used to complete the call. When local telephone companies convert to local number portability the 10-digit telephone number will no longer be feasible to route telephone calls across the telephone network. For example, if customers decide to change from their current local telephone company to a competitor and retain their telephone number, a different call routing scheme must be utilized. The new routing scheme uses a location routing number. However, before a routing number can be assigned, the customers must change service providers; this process is called "porting."

Porting is a complex process with a series of checks and balances built in to protect the customer. Perhaps you may recall the concept of long distance slamming? When a long distance company changes a person's long distance carrier without that person's permission, they have been slammed. In order to prevent local number portability slamming between competing telephone companies, seven Number Portability Administration Centers (NPACs) have been established in specific regions of the country. Their role is to maintain databases of all ported telephone numbers, and they are required to administer the transfer of customers from one telephone company to another. This process ensures a neutral third party is completing the transfer, guarding against fraudulent activity. The following describes the

process of porting (refer to Figure 1). First, the new competing local telephone company manages to win the business of a customer currently served by the telephone company that has been in the area for several decades referred to as the incumbent. In the parlance of telecommunications, the competitor is called the Competitive Local Exchange Carrier (CLEC) and the incumbent is called the Incumbent Local Exchange Carrier (ILEC). The CLEC forwards a porting request to the NPAC. Since the customer cannot be without telephone service even for a few minutes, the NPAC must also be made aware of the exact date and time to process the transfer. Next, the NPAC alerts the ILEC of the porting request. In some cases, the ILEC then contacts the customer to validate the request. The ILEC must then acknowledge the porting request to the NPAC and confirm date and time of the porting request. The NPAC confirms with the CLEC, ports the number, and changes the NPAC database to reflect the customer's new telephone company (America's Network, 1997). The customer has now changed service providers while retaining their original telephone number.

Once a customer's telephone number has been ported to a CLEC, the telephone number they have retained will no longer be utilized to route a call on the telephone network. When calling a person who has been ported to a CLEC, the caller will use the telephone number they have always used. However, network routing will now be completed with a location routing number instead of the original telephone number. The following describes how a telephone call would work to a ported customer (refer to Figure 1). First, a caller ('A') dials the telephone number of a person ('B') whose number has been ported to a CLEC. Caller 'A' dials the original telephone number he/she has always used to contact person 'B'. Second, caller 'A's' telephone company determines from routing tables that the number dialed is a ported number. The

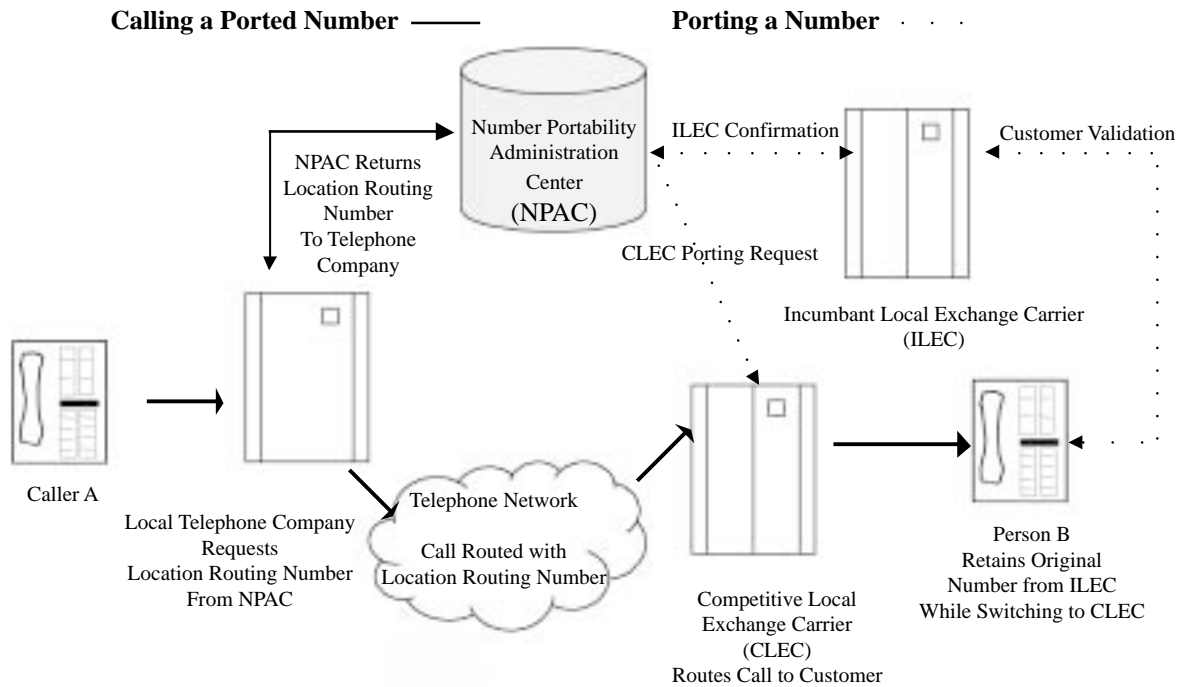


Figure 1. The process of porting a telephone number and the process of calling a ported number.

call asks the NPAC database to locate the initial routing number of the ported number. Third, the NPAC searches, utilizing the telephone number dialed to reach person 'B'. When a match is found, the corresponding location routing number is returned to caller 'A's telephone company. Fourth, caller 'A's telephone company uses the location routing number to send the call across the telephone network. Eventually, as more individuals change local telephone company service providers, all telephone calls will require NPAC database inquiries (Midwest Region Number Portability Administration Center, n.d.).

And the Future?

Should implementation of local number portability be successful, the new competitive telecommunications marketplace will eventually offer a variety of new services at lower prices to consumers eager to try new technologies. Implementation of local number portability means that all telecommunications service providers will have to compete with one another on the basis of quality, price, and type

of service. Local number portability levels the playing field, allowing consumers to choose the desired services from the desired providers at the desired price. When new services are created, consumers can simply request a change in service provider while retaining their original telephone number. Through competition, systems will be developed that eliminate the need for multiple telephone numbers, saving the North American numbering plan. This new system will allow individuals to communicate whenever, and wherever, with only one network address, which will serve as cellular, landline, Internet, and fax number.

Competition and limited regulation proves to be the best motivator for technological innovation within telecommunications. Still in its infancy, the Internet has been free to develop in absence of regulatory control. The FCC has repeatedly stated that the Internet should develop in a competitive market (Kennard, 1999). This competitive environment is creating a myriad of new technologies such as Internet telephony, web radio broadcasts, and online

e-commerce. However, if a regulatory environment pervades the Internet, technological innovation which benefit consumers will decrease just as it did for several decades in the telephone industry.

The new telephone industry will truly be competitive once local number portability is implemented. The new telecommunications service provider will have to discard a monopolistic mindset and think in terms of customer service and technologically advanced. While there will be more unique services available in the future, the smartest consumers will benefit the most if they choose wisely from all the available options. The most important issue, however, is how long the telecommunications industry will remain competitive. Rapid technological development in a competitive market may create more societal problems than benefits, requiring additional regulatory control, just like the early days of the telephone.

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Focus on Communication and Collaboration: Suggestions for Implementing Change in the 21st Century

Charles Linnell

If curriculum and teaching standards for technology subjects are to become a vital addition to the public school curriculum in the 21st century, then two important challenges must be resolved. The first is to communicate clearly, with solidarity, what technology education is and what technology educators do. The second challenge is

to prepare technology education teachers to collaborate in different school settings with teachers from different disciplines. Communication and collaboration efforts will teach public school students, educational policy makers, teachers, and others of technology education's cross-curricular value. School subjects such as language

arts, math, science, and social studies provide opportunities to develop the technology curriculum into the public school curriculum.

Communication

There has been considerable debate within the technology education community about its purpose and

mission (Volk, 1997; Wicklein, 1997; Zuga, 1993). Where is the profession going? Some of the central questions asked include the following:

1. Should the technology curriculum emphasize skills, technological systems and concepts, or a combination?
2. Where does it fit in the public school hierarchy? Can, and should, technology content be assimilated into the K–12 public school curriculum? If so, how?
3. Should technology teachers be the only ones to teach technological skills and concepts, exclusively? Or should preservice teachers, primarily elementary, have technological concepts, skills, and teaching strategies designed into their university curricula?

These questions, and others, need to be addressed in a succinct and proactive manner by technology administrators and practitioners.

The technology education profession is, and has been, immersed in an on-going change process for almost 20 years with varying degrees of success. Research has shown that changing established educational goals and curricula requires innovative change agents, facilitators, and coordinated strategies to assure success (Guskey, 1990). When teachers are involved in the educational change process, trained change agents can alleviate their personal concerns and anxieties. Two important factors in educational change theory are quality facilitation and trained, subject-specific facilitators who can be proactive and communicate well (Fuller, 1969). Bensen (1990), who studied curriculum change in technology, asserted, “To improve, one must change, and making change in any human endeavor involves some element of risk” (p. 3). After studying the concerns of technology teachers involved in the change from industrial arts to technology, the one concern that kept recurring most often was the anxiety that teachers felt when they were “mandated” to implement the new technology curriculum (Linnell, 1991).

The teachers were unsure of their abilities to master the requirements of the new “high tech” curriculum. The study found that after organized inservice activities and exposure to *proactive* change facilitation, the majority of the teachers were more confident and better prepared to work with the new curriculum. However, a substantial number were not. Openness to change has not always been one of our discipline’s strengths (or any educational content area).

The hesitancy and concerns that teachers have when they are involved in a curriculum change effort are usually concerns about their own ability to understand and work successfully with the anticipated curriculum requirements (Hall & Hord, 1984). These are serious personal concerns. In different locations specific technology teachers’ questions and concerns have been identified; in some places specific inservice and preservice strategies designed to assist teachers exist. Yet, the majority of teachers do not participate in state association activities, let alone alter the way they teach. Approximately one half of the teachers of technology subjects in South Carolina are members of the state’s technology education association. Only about one fourth of those are members of the International Technology Education Association (ITEA) and regularly attend the state association’s scheduled meetings. I contend that only with support from state government, proactive local education associations, qualified, enthusiastic, change facilitators, and an organized, well-funded public relations campaign will teachers be able to accept and take a personal interest in the technology curriculum. I also believe that this situation is not unique to South Carolina technology educators. However, there are some bright spots. Our neighbors, Georgia and Florida, have made funding technology subjects a priority. Their state teacher organizations and Technology Student Associations (TSA) are thriving and effective.

Technology professionals, from classroom teachers to the administrators

of the ITEA, are, historically, a fairly cloistered group. Their individual dedication, teaching, and research efforts are genuine and admirable. However, this hard work and fervor is going unnoticed by the public, specifically, public school teachers and administrators. This may stem from the fact that we do most of our communicating within our own profession, that is, *Tech Directions*, *TIES*, *The Technology Teacher*, *The Journal of Industrial Teacher Education*, *The Journal of Technology Studies*, *The Journal of Technology Education*, and others. In fact, how many other discipline’s research journals and mass-market publications, such as *Teaching K-8*, *USA Today*, and *Time*, have articles describing the processes, strategies, and positive student outcomes gained from the technology classroom and lab? Not many. The ITEA staff has been developing, and implementing, good public relations strategies. However, public relations campaigns are very expensive and, as Saunders (1999) suggested, “we” must get “political.” Saunders stated further:

If technology education is to realize its potential in the 21st century, we simply *must* become aggressively and outwardly political. Very little of real significance will happen in our field until we re-direct our energies and resources toward this task. (p. 26)

Collaboration and Flexibility

The lack of a clear curricular focus and the determination of some technology professionals to resist change does not bode well for our discipline. If the *Technology for All Americans* effort is embraced by the public schools in the United States, and K–12 students will be required to take courses that investigate technology, then technology as a field of study becomes important, a required part of all students’ education. However, if the *Technology for All Americans* movement is *not* accepted by the public, then we will need to do what we should have been doing since the change from industrial arts to technology: Collaborate with teachers from different subjects.

Understanding the objectives of a course of study is important for students and the public. Some basic questions make this point clear. What are the objectives of math and science education? What is the purpose of studying different cultures? Why should students be familiar with great works of literature? What is the purpose of vocational education? Ask yourself these questions, and the odds are that for each one you will have your own neat, compartmentalized understanding. However, when you ask someone, "What is technology education?" the answer could be anything. The answers are usually "computers" and/or "information or educational technology." This misunderstanding is slowly, and in some locations rapidly, blurring the quality goals and objectives of the technology curriculum, and renaming, reassigning, and even closing many technology classes and departments (Volk, 1997). Technology professionals have traditionally been "masters of their domain" with their own unique pedagogy, skills, and resources. However, if they want to represent a legitimate subject in schools yet still have a unique, collaborative reputation, then they must be prepared to accept change and communicate a willingness to be flexible.

Some of the public's (and even the profession's) difficulty in understanding who we are stems from the lack of a clear curriculum definition, course and

subject titles, and focus. Some of the different technological subject area titles are Industrial Arts, Industrial Arts Education, Industrial Technology, Industrial Technology Education, and Technology Studies, among others. If professionals in the technology field do not have a clear understanding of our mission, then how can we expect the general public to buy into the profession's efforts to standardize the curriculum?

It used to be that our mastery of techniques set us apart from other school subjects. Not any more. Technological innovations and changes are happening almost every day in business, industry, and technology. In order to keep up, *everyone* will have to retrain and reeducate themselves if they want to keep abreast of technological innovations. We have moved beyond the competitive mind-set of "America First." Now we realize that for the world's economies and social structures to succeed, we will *all* need to collaborate. It is the same with technology education. The goal of our profession is still to produce students who are conversant with different aspects of technology. Hopefully, by collaborating with teachers from other subjects and at all grade levels, the practical value of our discipline will become an integral part of the public school curriculum. The technology education profession must not hesitate to inform the public and the

education community that we are here and that we have unique skills, strategies, and content that will benefit the education of every student.

Recommendations

Hopefully, these following recommendations should assist the implementation of technology education and increase the awareness of technology educators:

1. Increase and improve communication and collaboration efforts with K–12 public schools via publications, inservice workshops, demonstrations, and by assisting future teachers in the implementation of technology concepts and activities.
2. Use the same positive communication and change facilitation strategies within the technology education profession, that is, to promote the value of cross-curricular collaboration, to improve solidarity and professional pride in professional technology education organizations, and to prepare future technology education teachers to confidently accept and implement change.

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Fostering Self-Directed Team Members

Robert T. Howell

The word *team* can mean different things to many people. To some the word *team* means playing a game together such as baseball, football, or basketball. These types of teams, because the outcome depends on their collective action, truly do function together as a team; team members either win together or lose together. For many the word *team* means simply working together on a project or special assignment. In education many schools use team teaching to indicate that two or more teachers work together teaching a class or particular subject.

This article offers a definition of what a self-directed team is, how it functions, how it functions in industry, and what team members need to know to work well in teams. The problems of finding highly skilled self-directed team members and how technology subjects can help prepare such people in the future are also addressed.

Self-Directed Teams

In the business world self-directed teams are increasing in importance and have a direct impact on the success and survival of many companies (Huszczko, 1996). According to Huszczko (1996), many Fortune 500 companies report having some sort of employee involvement program that involves self-directed teams. Forming teams has become a natural way of involving employees in their own improvement and ultimate success. Self-directed teams perform such duties as problem solving, quality improvement, self-directed work, serving on task forces, and new product launches. Huszczko noted that companies recognize that every employee in an organization has some form of expertise that can contribute to the success of the company. Huszczko also reported that teams have the following purposes and benefits:

- Provide an important source of stimulation.

- Create higher-quality solutions than most individuals working alone can create.
- Offer structure that encourages a sense of involvement in a large organization.
- Serve as a vehicle for organizational development efforts.
- Offer a means of satisfying relationship/belongingness needs.
- Provide a form for constructive conflict resolution.
- Provide an opportunity for more individuals to develop and utilize leadership skills to fulfill personal needs.
- Improve productivity through using flexible approaches to problem solving.
- Construct a structure that helps employees appreciate everyone's crucial interdependence for the organization to succeed.

Success of Self-Directed Teams

Many books document the success that companies report since installing self-directed teams in their organizations. Wellins (1994) identified companies showing an increase in profits ranging from 50% to 100% after changing to a team environment. Wellins pinpointed the areas that have reported particular success with teams:

- **Cost Savings:** Organizations empower their teams to work on continuous improvements. These savings can be enormous—as reported by RCAR Electronics, whose self-directed teams recorded a savings of \$10 million annually. Wilson Sporting Goods achieved annual savings of \$5 million, while the Harris Corporation reported average savings of \$4.5 million.
- **Labor Productivity:** Teams enable organizations to do much more with less. Reduced costs in production show up in the profits reported by corporations: K Shoes

reported a 19% increase in productivity, Sterling Wintrip had a 40% increase in production, and Kodak Customer Assistance Center showed a 100% increase in profits.

- **Quality and Service Improvement:** Every company must not only focus on doing business at a lower cost but also on doing things better. Since quality is often measured by the rate of customer complaints and returns; companies reported lower customer returns and rework because of a teams-directed approach. The list of companies that have used this successfully include the following: Texas Instruments, whose return rates dropped from 3% to .3%; Westinghouse, which reported rework down by 50%; and Tennessee Eastman, which ranked first in customer satisfaction among its competitors.
- **Speed:** Doing things faster is yet another competitive edge in today's corporations. Teams deliver reduced down time and turn-around time. Companies such as RCAR reported cycle time as having been reduced by 40%. K Shoes reported that it reduced the time it takes to make a pair of shoes from 12 days to 1 day.
- **Human Resource Benefits:** Teamwork affects other things within a corporation: it increases loyalty, it induces less absenteeism, there are fewer worker compensation claims, and there is lower turnover.

What Employers Want and Teams Need

The paradigm of what employees need to know and what tasks they should be performing has shifted. As Murdock (1999) stated, jobs requiring the most education and training are growing at twice the rate of those requiring less education and training.

This paradigm has been changing so much that lower level jobs require higher levels of education. Murdock further stated that today's employers are demanding higher levels of communication, planning, and problem-solving skills. Their lists of demands also include self-esteem, motivation, learning how to learn, reading, writing, computation, listening, and oral communications. Many employers expect higher level skills such as creative thinking, problem solving, goal setting, career development, interpersonal skills, negotiation, teamwork, organizational effectiveness, and leadership.

Trunk (1995) believed that employees in the year 2000 would need strong technical skills along with greater managerial capabilities. Trunk believed that fewer workers with both technical and social skills needed to be a team member would be scarce, in part, because public schools are not turning out enough qualified candidates quickly enough to meet the demands. Trunk also noted that workers in the 21st century must be able to analyze what is going on at their work site and communicate what they see in order to make decisions to increase productivity and eliminate marginal issues.

Education and Self-Directed Teams

A study conducted by Verespej (1998) found that 62% of what employees needed to know was acquired through informal learning in the workplace. These conclusions were reached after two years of research inside the manufacturing plants of seven high-performance plants in the United States. Verespej reported that only 12% to 18% of the workers surveyed said that formal training taught them skills needed to succeed in a self-directed team environment. The skills these workers felt they needed on a self-directed team included problem solving, interpersonal communication, and handling conflict. Verespej concluded that "the vast majority of learning by workers is not in the classroom or in formal training,

but most learning occurs in the pursuit of everyday work activities" (p. 44).

Finding self-directed team members who are highly skilled and can meet a corporation's needs may prove to be a problem. Although technical colleges are preparing motivated young adults to fill entry-level jobs, many employers face a dearth of highly skilled employees (Trunk, 1995). As Trunk (1995) stated:

Companies must look to their own employees now, screen them and develop the kinds of workers needed from their own ranks. This is much easier than trying to find new workers who have not proved themselves day-in and day-out. (p. 11)

Today's Students/Tomorrow's Self-Directed Team Members

As many of the Fortune 500 companies move towards self-directed teams, new types of employees will be needed in this new century. Technology studies must stay abreast of this paradigm shift and change how students are educated. Employers are looking for future employees who have problem-solving, interpersonal communication, and conflict-handling skills. The question is: How best do we meet these needs in technology studies? The answer is obvious: We can meet these needs through projects designed to involve groups of students who work and solve problems together.

Because he concluded that problem solving is limited in technology studies, Todd (1999) believed that students would be better served in programs built around "design" in which problem solving starting at the elementary school level is taught. Design not only encourages problem-solving thinking, but it also fosters group interaction, investigation, creating, planning, testing, evaluation, and improving.

Technology studies can best train people to problem solve through the proper design of projects—projects that will inspire students to be problem solvers, communicate with each other, and handle conflicts that may arise in their group. Technology studies is the perfect place to teach students how to

work as team members. The importance of selecting the right project, one that will teach the values of teamwork, is important. As Schultz (1999) noted, the importance of technology studies comes from the project method. In Schultz's article "Why Do We Teach What We Teach?" he answered this question by saying, "We teach tool and material use and in doing so, we teach people the project method" (p. 84).

The question now arises: How best do we teach the proper project in technology studies? Can students learn how to problem solve and work in groups by sitting in cubicles? Schultz (1999) asked this same question: Do we teach the project method by having students problem solving and building projects the traditional way or do we teach them in library-type cubicles, at computer terminals using software modules developed by vendors? The answer to this question seems obvious. We need to expose students in technology studies to the more traditional system of project design and development in order for them to develop problem-solving skills and learn work.

Historically, a lot of researchers wrote about the disadvantages of teaching problem-solving skills in a module type presentation. A study by Rogers (1998) showed that technology studies students in a contemporary class setting exhibited significantly better achievement rates over students in modular technology studies classes. Pullias (1997) also noted students in modular labs do not learn how to develop problem-solving skills. They are adroit at following directions, but they do not develop a true understanding of the various concepts being taught. Dugger (1999) pointed out that technology studies provides students with active learning experiences that add meaning to cognitive knowledge. What a better place for students to learn about teamwork while learning about the real world.

Technology studies educators must begin to change their curricula to include problem-solving design

activities that encourage teamwork. As Wellner (1999) stated, "Most of them (high school students) are still teenagers, but their inclinations already portend a different kind of work force" (p. 42). Wellner reported that the secrets of success are getting along with others, working well on teams, and getting along with members of different racial and ethnic groups. Many of these values can be traced back to the classrooms in

public schools whose teachers emphasize teamwork and grade students on their ability to get along with other people. Most teens stated that they would be more interested in being a member than leading it or owning a company (Wellner, 1999).

Technology studies educators must prepare to make the changes to maximize teens' movement into the job market. When they do, employers will

have the people they want—ones able to function well in teams and contribute meaningfully to the success of their companies.

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Enriching the Undergraduate Experience Through a Technology Learning Community

Steven A. Freeman, Dennis W. Field, and Michael J. Dyrenfurth

This article describes the implementation of a learning community as a model for enriching the undergraduate experience in the Industrial Technology curriculum at Iowa State University (ISU). The authors sought to incorporate effective practices learned from a variety of

sources and to increase both achievement and retention. From this three-year project, the authors then provide recommendations for other industrial technology faculty interested in establishing learning communities within their programs.

Teaching and learning are at the

heart of the undergraduate experience. Educators and researchers have expounded on the benefits of alternatives to straight lecture-based university education (e.g., Finkel, 2000; Freeman & Field, 1999; Hull, 1995; Johnson, Johnson, & Smith, 1998; McKeachie, 1999; Perlman, 1997;

The learning community initiative in the Department of Industrial Education and Technology was supported in part by a special allocation from the Iowa State University President's Office.

Thomas & Rohwer, 1993). This body of research stresses the importance of methodologies such as cooperative learning, peer learning, experiential learning, and contextual learning. The avowed goal is to develop in students what Thomas and Rohwer (1993) called "proficient autonomous learning." Collaborative interactions have been shown to increase student academic performance, student retention, structured thinking, and improved ability to work together (American Association for Higher Education, 1998). The authors' position is that students' out-of-class experiences can benefit from this approach as well. While many of the ideas incorporated into learning communities are not new, the advent of structured learning communities yields a unique new framework for combining and institutionalizing these concepts within current curricula and the constraints imposed by university culture.

Learning Communities

Cross (1998) defined learning communities broadly as "groups of people engaged in intellectual interaction for the purpose of learning" (p. 4). Shapiro and Levine (1999) categorized learning community models as paired/clustered courses, freshman interest groups, team-taught programs, and/or residential learning communities. Lenning and Ebbers (1999) considered learning community models to be curricular, classroom, residential, and student-type. Regardless of the classification scheme used, learning community models can be grouped by the types of activities and students involved. A generic categorization may be as follows:

1. *Collateral course-based learning communities* occur when students take two or more courses together as a cohort group. There is, however, an endless variety of ways in which to structure cohort types of learning communities. They may involve only two classes or the students' entire schedule for one or more semesters. The

classes may be traditionally taught courses or team taught across disciplines. The courses may be discipline based or cross-disciplinary theme based.

2. *Residential learning communities* occur when students live together, often in a dormitory. They may or may not take common classes. This type of learning community strives to integrate the students' living and academic environments (Shapiro & Levine, 1999).
3. *Freshman interest groups* are learning communities where entering freshman with a particular subject interest, and not necessarily in the same major, take grouped or linked courses around that area of interest.
4. *Student type learning communities* are designed for special sub-populations (e.g., honor students, students with disabilities), and they may or may not involve common courses or living arrangements.

Learning communities may be structured following one of the described generic models, or any combination of the models, or an entirely different model. Clearly there is more than one correct way to implement a learning community. Rasmussen and Skinner (1997) offered the following advice:

The best design will depend on institutional environment and the specific disciplines to be integrated as well as the characteristics of the faculty and students who will participate. The goal is to provide a richer range of learning experiences to our students and contribute to a more vibrant and supportive campus environment for students and faculty alike. (p. 15)

The essence of learning communities is, however, clear. They are collaborative learning environments designed to increase student interaction with peers and faculty. Because of this, many colleges and universities across the country are turning to learning communities as one way to increase retention and student satisfaction with

their programs (Lenning & Ebbers, 1999). There is also correlational evidence that students who participate in learning communities show more intellectual growth and get more out of their college education than less involved students (Cross, 1998). Although the literature evidenced no articles pertaining specifically to learning communities in a technological program setting, the benefits ascribed to them suggest that they have potential for positive impact on industrial technology programs.

The ISU Experience

Because of a university-wide belief in the value of learning communities, since 1995 approximately 40 learning communities have been implemented across the university. At first, the possibility of a learning community in industrial technology was discussed but not pursued because the student population in industrial technology did not easily fit into any of the standard learning community models. Faculty observations indicate that most incoming ISU industrial technology students are transfers with few remaining general education requirements. Few are traditional freshmen. ISU's entering industrial technology students tend to be older, with previous work experience, living off campus, commuters, married, and with an established network of friends. These characteristics prevented use of either of the two most common learning community models: collateral course-based learning communities or residential learning communities.

After reconsidering the possibilities, and with partial funding from the university, the authors began an initiative in 1999 to develop and implement a nonresidential, non-collateral course-based technology learning community model. This Technology Learning Community (TLC) is designed to function as an induction and support activity for freshmen and transfer students in the Department of Industrial Education and Technology (ITEC). The TLC helps

entering students maximize their educational experience, regardless of their academic stage, and it systematically begins their professional acculturation within the discipline of industrial technology. TLC participants are grouped into small clusters of four to eight students. Each student cluster works with a peer mentor, an industrial mentor, a graduate assistant, the academic advisor, and industrial technology faculty members. Specific goals of the TLC initiative include (a) orienting freshman and transfer students to the discipline and profession of industrial technology; (b) connecting new students to each other using cooperative learning groups; (c) connecting new students with faculty, upper-class students, and professionals in industrial technology; (d) introducing the variety of professional roles available through an industrial technology degree; and (e) assisting students in developing realistic self-assessments, career goals, and academic goals.

Credit Coursework and Out-of-Class Activities

During their first semester of participation in the TLC, all students take a 1-credit Introduction to Industrial Technology course. TLC students participating in a second semester are able to again participate in a TLC group and may also choose to register for the Introduction to Industrial Technology course again (although only one counts toward graduation requirements). Each semester TLC students also enroll in an appropriate selection of collateral courses to maximize their progress and success in the Industrial Technology program. It should be noted, however, that the selection of collateral courses is not common to all TLC students due to the typically wide variety of previous academic experiences of these students. In any case, full-time students participating in the TLC are expected to enroll in courses each semester that are balanced between departmental courses and the completion of required general education courses.

Out-of-class activities are systematically incorporated as part of the TLC because of their impact on students. Each TLC cluster is assigned an industrial mentor who is an integral member of the TLC. Students initiate and maintain contact with their industrial mentor through phone, online, or face-to-face communications. These mentors work with students to help them get a realistic view of the professional life of an industrial technologist. The students submit resumes and portfolios to industrial mentors and receive comments and counseling on the documents. Students are expected to set up and attend at least one industrial tour (independent of any tour taken as part of a course) and at least one social activity of interest to their TLC cluster. TLC members are also introduced to student chapter activities of honorary and professional societies, such as Epsilon Pi Tau, the Society of Manufacturing Engineers, the Society of Plastics Engineers, and the American Society of Safety Engineers.

Peer, Faculty, and Industrial Mentors and Graduate Assistants

Peer mentors are a key component to the success of the TLC. The peer mentors have the most direct (i.e., weekly) contact with the TLC participants. Their role is part tutor, part group facilitator, part social director, part ITEC and campus master, and full-time friend. They facilitate all TLC cluster activities and are the first link to the rest of the TLC mentoring team. They are expected to actively participate in the planning and operation of the TLC initiative.

Three faculty members serve as mentors and as secondary resources and advisors for the TLC students and for the peer mentors. They also handle administrative tasks and provide direction and supervision to the TLC graduate assistant. The responsibilities and duties of the faculty mentors include providing long-term strategic direction regarding the TLC initiative; recruiting and selecting peer and industrial mentors for the TLC;

designing, developing, and administering learning community assessment and evaluation initiatives; and actively pursuing funding possibilities for TLC activities.

Industrial mentors are a unique component of the TLC. The primary purpose of including industrial mentors in the TLC is to help students understand the relevance of their experiences at ISU to their future success on the job and to communicate a sense of industry's expectations. Industrial mentors help to bridge the gap between students' perceptions of what they need to do to be successful on the job and the expectations of future employers. The responsibilities and duties of the industrial mentors include providing realistic, credible feedback to students in a number of areas (e.g., resumes, portfolios, what employers look for in prospective employees, program of study and course selection, career options) and suggesting appropriate activities for TLC students to enrich their education at ISU.

A graduate assistant handles the day-to-day management and activities of the TLC and serves as the first line of contact and assistance to the peer mentors. Among other things, the graduate assistant provides direct supervision to the peer mentors; assists the peer mentors and the TLC students in accomplishing their goals and objectives; assists in the preparation and presentation of the Introduction to Industrial Technology course; maintains TLC records; and assists faculty with assessment and evaluation components of the TLC.

Assessment

The goal of the assessment process within the TLC initiative is to document student growth in a holistic manner and to evaluate the initiative's performance. To this end, pilot studies using a variety of assessment tools (e.g., *The Productivity Environmental Preference Survey (PEPS)*, a learning styles assessment [Price, 1996]; peer and student evaluations; *Technology Literacy Instrument* [Dyrenfurth, 1990]; the

ACT Work Keys® system from American College Testing, Inc. [ACT, 1999]; and ISU's *Undergraduate Education Survey* [Epperson, Huba, & McFadden, 2000]) have been initiated. Clearly student and TLC assessment is a long-term process. Currently the initiative is in a developmental and benchmarking stage, and during the next academic year it will transition to a more summative assessment. Questions of particular interest to faculty include:

- Did the TLC activities take place as planned? If not, what were the reasons?
- Did the peer mentors, industrial mentors, and faculty-scholars communicate effectively with TLC students and work toward an appropriate supportive environment?
- Did TLC students have the opportunity to engage in inquiry-based activities?
- Was there an appropriate balance of academic and social support?
- To what extent did the TLC students benefit because of their participation in the TLC? Which activities and information were most often incorporated in the TLC program?
- To what extent did TLC students share their acquired knowledge and skills with other TLC students? Which topics were frequently discussed? Which ones were not?
- To what extent was there an impact on the TLC students? Had they become more (or less) positive about their discipline and departmental choice?
- Did changes occur in the overall program of instruction offered to Industrial Technology students? What were the obstacles to the introduction of changes?

Reflections, Conclusions, and Recommendations

The authors have been implementing and evaluating the TLC model since 1999. During this time, student feedback and faculty reflection yielded the following observations. Through interaction with peer mentors and

industrial mentors, TLC participants begin to place their educational experiences in the context of an industrial technologist's role. This interaction aids students in developing awareness of the dimensions of their future professional role and the associated expectations. Through their interaction with industrial mentors, TLC students have continual opportunities to discuss the importance of coursework and receive feedback and positive reinforcement regarding the relevance of academic topics.

Student reactions, both peer mentor and participants, were cool at first. After all, this was something outside of their academic experience. They seemed to be saying: "What is the TLC anyway? What is a learning organization? You mean those professors still have to work at learning? I thought they knew it all already!"

The peer mentors seemed to focus on the process and having fun with the TLC students, while the industrial mentors seemed to be more outcome oriented. Both, however, were uncomfortable with the initial lack of structure for the TLC. They certainly reacted positively as their roles and associated expectations became clearer. Peer mentors discovered what responsibility for others was—especially while facing their own pressures.

The TLC's graduate assistants attributed the students' increased appreciation for the importance of intergroup communication to their weekly peer group meetings. Students also found out that self-awareness came at the price of time. They discovered that they cannot really know where they are regarding any knowledge curve without testing, analysis, and reflection. One setting remembered by the authors was particularly powerful in establishing this. At an informal group meal, about 30 students, peer mentors, industrial mentors, and faculty began reflectively sharing things that had been important to their advancement. Looking around the room, everyone was focused, attentive, and reflecting—no blank or glazed eyes here!

Overall, the authors deemed the experience a positive one. However, the challenges turned out to be far more significant than what was envisioned. Far more time was required, often in surprising directions. For example, getting other faculty colleagues to value what the authors thought to be self-evident and desirable was surprisingly difficult. Similarly, the task of detailing a holistic assessment plan and instrument set has required considerably more time than anticipated.

Significant institutional support was available, but because the TLC did not fit into conventional learning community models, the institution occasionally overlooked TLC activities. The communication requirements, both internal and external, to initiate and sustain the TLC initiative were larger than expected. Effective learning communities clearly demand both joint activity and individually discrete activities done in collaboration.

After completing several semesters with the TLC, the following conclusions can be shared:

- Learning communities can become worthwhile, but they require significant commitment of time and resources beyond those assigned to normal course instruction. However, the responsibility to encourage learning that transcends the traditional bounds of class-based courses will make the investment worthwhile.
- Since suitable holistic measures for assessing the overall development of technology majors have not been located, it is incumbent on the profession to meet this need. To this end, the *ACT Work Keys*® (ACT, 1999) and the *Technology Literacy Instrument* (Dyrenfurth, 1990) are undergoing evaluation.
- Student response to the TLC seems to be favorable although voiced with the reserve that is typical of today's students.
- The development of a learning community is clearly a long-term effort. The entrenched notion that learning should be packaged

primarily into conventional courses delivered by faculty is hard to dislodge. The selling of the concept of “not letting one’s coursework interfere with one’s learning” is a challenge—but not an insurmountable one.

For readers interested in initiating a learning community of their own, or in enhancing an existing one, the following recommendations are transportable to other settings:

- Get the learning community’s overarching goals on paper and then interactively refine them with the active participation of the department faculty, industrial mentors, and peer mentors.
- Lay out the expectations for peer and industrial mentors carefully and explicitly, and then develop a monitoring mechanism that operates on a weekly basis.
- Develop a plan of work that operationalizes each goal with activities planned throughout the duration of the experience (typically a semester). Additionally, it seems important, particularly in the early stages of implementation, to include a structured and shared

community time block so that a natural event exists where all parties come together.

- Implement a viable reward system for all participants. Each person (student, mentor, faculty) has to be able to derive satisfaction from his or her participation. This system must transcend “credits”—it must provide other rewards (e.g., psychological) as well. For example, students must perceive value in their activity, mentors must believe they are helping, and such work should be of value when faculty document their teaching for promotion and tenure decisions.
- Faculty and staff should consider the various learning community models described in the literature. More important, they should visit and interact with the staff of existing learning communities. These initiatives are all about people and the sharing of their experience, insights, and, above all, caring. Such dimensions typically do not communicate as well in print as in person.
- Existing introduction/orientation courses and experiences should be

evolved into structured learning communities. A learning community integrated into a department’s programs in this way has the advantage of being institutionalized and yet it offers the opportunity for the personal interaction and collaborative aspects that are at the heart of learning communities.

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Some Essentials of Diversity in the Workplace

Robin Williams

This article presents selected concepts in support of diversity in the workplace and the elements of the processes that lead to success in implementing diversity training programs within a multiculturally diverse workplace. Diversity training requires an appreciation for change and ought to be viewed as a resource within every company (Hendricks, 1991). This is closely connected with the fact that America's workforce is changing. By 2050, the African American population in the United States is expected to nearly double to more than 61 million people. Every year from now to 2050, the Hispanic-origin ethnic group will add the largest number of people to the U.S. population under age 18 (Bell, 1999).

The Why and What of Diversity in the Workplace

McEnrue (1992) observed that managing diversity can serve as a source of competitive advantage for a firm in six ways: (a) by reducing costs associated with excessive turnover and absenteeism, (b) by making it easier to recruit scarce labor, (c) by increasing sales to members of minority culture groups, (d)

by promoting team creativity and innovation, (e) by improving problem solving, and (f) by enhancing organizational flexibility.

As the workforce changes, there is an increasing demand for companies and managers to be more sensitive to cultural diversity. Technology is available to everyone today, so what really makes a difference to an organization is people and how effective they are in maximizing their potential (Bell, 1999). Facilitating diversity does not mean focusing only on the needs of minority employees. Rather, managing diversity is getting all employees to perform to their potential by tapping the potential of all workforce members. Facilitating diversity does not mean simply being anti-White male, for example. It means accepting the range of variations among persons by virtue of their age, education, social class background, job function, and personality style. The goal of diversity is not to assimilate women and minorities into a dominant White male culture, but to create a heterogeneous organizational milieu (Thomas, 1990).

Thomas (1990) explained that managing diversity is creating an

environment that allows access to the talent of people who are increasingly diverse. In this type of environment, people would feel free to behave differently as a result of their ethnic differences (Comeau-Kirschner, 1999). Effective management of a diverse workforce translates into bottom-line results. Diverse groups tend to be more creative problem solvers when their differences in background and perspective are all brought to bear. Diverse companies, therefore, have the potential to be more innovative (Kuczynski, 1999).

According to Thomas (1990), the traditional American image of diversity has been assimilation: the melting pot, where ethnic and racial differences were standardized into a kind of American puree. Of course, the melting pot is only a metaphor. In real life, many ethnic and most racial groups retain their individuality and express it energetically. What we have is perhaps some kind of American mulligan stew; it is certainly no puree. At the workplace, however, the melting pot has been more than a metaphor. Corporate success has demanded a good deal of conformity,

and employees have voluntarily abandoned most of their ethnic distinctions at the company door. Now those days are over. Today the melting pot is distinguishable broth; you can't do the same with Blacks, Asians, and women. Their differences don't melt so easily. Second, most people are no longer willing to be melted down, not even for eight hours a day. Third, the thrust of today's nonhierarchical, flexible, collaborative management requires a 10- or 20-fold increase in our tolerance for individuality (Thomas, 1990).

Accepting the Concept of Diversity

A simple probe to discern the existence of a diversity effort is: Does this program, policy, or principle give special consideration to one group or to everyone's success? If the answer is one group, diversity is not being facilitated; if all employees are assisted, diversity is enhanced (Thomas, 1990).

The path to cultural enlightenment moves through six stages. The basic movements are from stage one "denial" and rigidly maintaining a belief system that there are no differences between cultures. Individuals who feel threatened by cultural differences are in the stage two "defense." "Minimizers" are at stage three and believe that cultural differences are only superficial—that we all are basically "the same." Individuals in the fourth stage demonstrate "acceptance" that there are differences between cultural groups and they welcome the opportunity to learn of other's preferred communication and behavioral styles. Being able to understand different frames of reference in the sense of an ability to "walk in another's shoes" is the fifth stage, "adaptation." "Integrators" at the last stage have incorporated the values and mores of more than one culture, and they have developed a dual or multiple identity (Bennett, 1986; Bergh, 1991).

Achieving and Managing Diversity

CEOs of high profile firms such as Avon, Xerox, Corning, and Procter and Gamble have said that managing

diversity is "not simply something to do because it's nice." Rather, it is a "competitive necessity," a "business imperative," a "strategic priority" (McEnrue, 1992). In a survey of 27 companies, *Work* newsletter found that most of the companies have employee diversity groups, often instituted as part of recruitment and retention strategies ("Survey Looks at Workplace," 1999). Diversity groups are sometimes called affinity groups, networks, or identity groups and are formed on the employee level. Study findings include that 74% of the respondents had diversity groups, while the other 26% either did not have groups or were considering them. Respondents with diversity groups included Microsoft, Intel, and Procter and Gamble. Seventy-five percent of respondents said that their employee groups contributed to diversity initiatives with their companies ("Survey Looks at Workplace," 1999).

To manage diversity, some companies encourage small group discussion. The small group process is frequently used in interracial discussion sessions that can enhance cross-cultural communication and acceptance. A belief in sharing responsibility for change is also promoted so that, for example, English-speaking employees should be as willing to acquire facility in speaking Spanish as Hispanic employees should be responsible to learn English. Included also is awareness training to encourage individuals to acknowledge how their stereotypes can impact decision-making actions toward others (Nelton, 1998). In order for those in positions of authority to "walk the talk," and to avoid unintentional discrimination, they must ask themselves the following questions: Am I considering all of our talent in hiring, promotions, and project assignments? Whom do we consider high-potential? Who is being promoted? Do we tell employees not on our high-potential list how to improve? (DeVoe, 1999).

Managing diversity also means creating a corporate environment where women, Blacks, and other non-traditional employees can flourish. And

diversity itself can be a source of strength (Konrad, 1990). According to *Business Week's* "Best Companies for Women" (Konrad, 1990), the following companies are pacesetters in the race to employ a "woman-friendly culture" within their companies: Avon, CBS, Dayton-Hudson, Gannett, Kelly Services, and U.S. West.

Following are some of the actions that companies have taken to manage diversity:

Avon initiated awareness training at all levels. "The key to recruiting, retaining, and promoting minorities is not the human resource department, its getting line management to buy into the idea. We had to do more than change behavior. We had to change attitudes" (Thomas, 1990, p. 108). Avon formed a Multicultural Participation Council that meets regularly to oversee the process of managing diversity, and in conjunction with the American Institute for Managing Diversity, Avon developed a diversity training program. Finally, Avon helped three minority groups—Blacks, Hispanics, and Asians—form networks that crisscrossed the corporation in all 50 states. Each network elects its own leaders and has an adviser from senior management. In addition, the networks have representatives on the Multicultural Participation Council, where they serve as a conduit for employee views on diversity issues facing management.

Corning's CEO James R. Houghton views managing diversity as "simply making good business sense" (Thomas, 1990, p. 110). Under his leadership Corning has expanded its summer intern program, with an emphasis on minorities and women, and established formal recruiting contacts with campus groups such as the Society for Women Engineers and the National Black MBA Association. Corning sees its efforts to manage diversity not only as a social and moral issue, but as a question of efficiency and competitiveness.

Digital established a resulting program and philosophy, called Valuing Differences, which has two components:

(1) There are voluntary groups with a trained facilitator to help people get in touch with their stereotypes and false assumptions, which Digital calls Core Groups. (2) Digital has named a number of senior managers to various Cultural Boards of Directors and Valuing Differences Boards of Directors. These bodies promote openness to individual differences, encourage younger managers committed to the goal of diversity, and sponsor frequent celebrations of racial, gender, and ethnic differences such as Hispanic Heritage Week and Black History Month. Digital wants to be the employer of choice. (Thomas, 1990, p. 111)

The need for companies to establish some type of diversity management is essential to maintaining a productive workplace in the 21st century. Companies are being forced to deal with employee relations or simply lose customers and thus profits. The overall consensus of many organizations about diversity management is that it's not established out of legal obligation or altruism, but bottom-line common sense (Konrad, 1990).

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The 2000 Paul T. Hiser Exemplary Publication Award Recipient

Mark E. Sanders

“Web-Based Portfolios for Technology Education: A Personal Case Study”

The Board of Editors of *The Journal of Technology Studies* and the Board of Directors are pleased to announce the recipient of the Paul T. Hiser Exemplary Publication Award for Volume XXVI, 2000.

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