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From the Editor

An (Articulated K-12) Curriculum to Reflect Technology

Precisely fifty years since Warner (1947) presented "A Curriculum to Reflect Technology," and with phase two of the Technology for All Americans Project now underway, we enter the most critical phase in the history of our profession. Our work over the next decade will either thrust us into the mainstream of the technology in education movement—or, it won't. The struggle for recognition of technology as legitimate subject matter in our schools is now behind us. Even the staunchest luddites recognize that "technology" isn't some passing fad. Technology educators are no longer alone in the call for technology in the curriculum. Every parent wants his and her child reap the benefits of technology in education. The only questions remaining have to do with the what, who, and how "technology" will be infused across the curriculum.

I wish we could assume credit for this awakening. After all, we've been championing the cause for half a century. Others, most notably those in the Science, Technology, and Society movement, have shared our passion for technology as content. But the message, for the most part, never rang loudly beyond our profession, and is only now beginning to be heard by "outsiders." Though we would like to take credit for this "paradigm shift" and have it guided by our vision, that is not the way it seems to be unfolding. The current frenzy regarding technology in education is a phenomenon of much broader proportions than our profession. This cause is now celebrated by all who have—at one time or another—experienced the power and wonder of the digital revolution.

We can be self-righteous in our understanding that "technology" is more than *just* computers. But the fact remains that computers *are* technology to virtually everyone outside our field. For them, the equation reads: *Computers = Technology*. We can evangelize all we want that technology is more than just computers... but precisely where that argument will lead us in the next decade is a matter of conjecture. Do we really believe educational decision-makers will put their resources in "production systems" or even "physical systems" before funding "digital systems?" Because of vocational funding, we have been able to dodge this issue in the past. How long can we continue to do so while chanting "technology for all Americans?"

The fact is, most of the processes we have taught in our field now originate with computer input devices—at least such is the case in the "real world." *Communication Systems* are all about bits these days. Most *Production Systems* begin with digital CAD systems, which generate code that drives machining equipment. *Power / Energy / Transportation Systems* are now routinely simulated with digital technologies. The concepts and processes of technology can and will be taught via digital systems.

Thus, anyone capable of operating a desktop computer is able to deliver something that most people believe is "technology education." Modular lab vendors have made it so, and they are exploiting this perception at an alarming rate. Witness the latest manifestation—the modular lab for the elementary school. Applied Technologies is now marketing "KidTracs™ Techno-Plaza and Theme Park" for the under-12 crowd. With modular labs for the elementary, middle, and high schools, Applied Technologies now offers some form of "technology education" from grades K through 12. School districts that purchase all three modular labs would have instant K-12 technology education; an inevitability that should give us cause to ponder. Is *this* the "technology education" we believe is best for the future? School districts and administrators will find these turnkey K-12 solutions irresistible as they go for the 21st century gusto.

At Virginia Tech, we now have a small but growing stream of graduate students entering our Technology Education Program who, despite having *no* background in our field, have been thrust into a modular lab (on the assumption that anyone can teach in such a facility). They are coming to us for the obligatory certification coursework. Sadly, the broad understandings and synthesis of ideas generally thought to be the stuff of graduate programs is of relatively little use to them in their modular labs. This phenomenon poses new challenges for our profession as we prepare technology teachers for the next century.

If the digital revolution and modular labs weren't enough to challenge our sensibilities, the Internet certainly ought to! The astonishing growth of the Internet/World Wide Web is taking education by storm. Every sector of the school is being impacted by networked information systems, beginning with the library and administration and extending outward from there. If those networks don't stretch to the technology education labs, we will be "road-kill on the information highway," as the cliché now reads.

Any one of these three "revolutions"—digital, modular labs, and networked information systems— would be astonishing by itself. All three assembled together in any given school system will provide convincing evidence of "technology education" in action. The problem is, they require little or none of our involvement. At a time when all of America, from the Clinton administration to the local PTA, is clamoring for "technology" in our schools, we will see a staggering increase in modular labs, computer workstations, and Internet connections at all levels and in all precincts of education. Computer labs will give way to networked "distributed computing" throughout the schools, as teachers increasingly demand computers in their classrooms. Soon, teachers in all disciplines will be involved in "technology education."

Technology *is* making its way into the schools and into the curriculum, and it is happening in spite of the field we call "technology education," not because of us. Computers, modular labs, and networked information are rapidly changing the ways schools do business. The brand of technology education being put in place isn't the sort we might have envisioned, but it certainly is "technology education" in everyone else's eyes.

It seems to me we have several opportunities/responsibilities amidst this changing landscape. First, we must continue to demand (by way of our purchasing decisions) more flexible modules from vendors whose primary motivation is sales rather than education. "Modular" instruction needn't be inherently bad, just as "technology" isn't inherently bad. Modules are what we make of them. We need modules that offer open-ended problem solving opportunities, not modules consisting only of lockstep procedures masquerading as "education."

Second, we must do everything within our power to make certain the school network makes its way to the technology education laboratory. Any technology education program excluded from the school network might just as well be located on a different planet, since "intra-school" communication would thus be easier from a networked program on the other side of the globe than it would be from the non-networked technology education lab in the school.

Finally, and most importantly, we *must* develop an articulated K-12 curriculum for technology education. As fundamental as this task may seem, no one seems to have taken it on. What concepts/processes/principles of technology do we think *should* be taught to a kindergarten student? What concepts/processes/principles of technology should follow this formative kindergarten experience in first grade? We must ask this question of each grade level from kindergarten through high school. We have never addressed this fundamental issue because technology education has never been a required subject from kindergarten through the 12th grade. The sooner we have this "vision" in place, the sooner we can move it to the public agenda.

The standards to be developed by the Technology For All Americans Project may be the key to the K-12 curriculum that we so desperately need. But, as important as they will be, I'm not sure we can afford to wait for "The Standards." We desperately need an *Articulated K-12 Curriculum to Reflect Technology* that we can forward to the public *right now.* Computers, modular labs, and the Internet are forcing our hand in this. We have worked on pieces of this curriculum for the past fifty years; yet ironically, we've never taken the "systems approach" to the development of a K-12 curriculum. We have yet to conceptualize a comprehensive, articulated K-12 technology education model. I think we can assume the modular lab vendors will get around to this task sooner or later—and when they do, it will be that much more difficult for us (or anyone) to forward a less commercial, more pedagogically sound model. It's time for an *Articulated K-12 Curriculum to Reflect Technology* to take shape!

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Warner, W. E. (1947, April). *A curriculum to reflect technology.* Paper presented at the annual conference of the American Industrial Arts Association, Columbus, OH.

Guest Article

Technology Education and the Search for Truth, Beauty and Love

William S. Pretzer

In her *Parade Magazine* column, Marilyn vos Savant, identified in the *Guinness Book of World Records* as holder of the world's "Highest IQ," responded to a letter writer's earnest question, "Is there anything in the world *not* affected by technology?" Her answer: "Yes. There's truth, beauty, love and the hiccups" (vos Savant, 1996, p. 18). Leaving the hiccups for later, here I would like to suggest that technology actually embodies and actively promotes specific versions of "truth, beauty and love" (Mitcham, 1995; Chandrasekhar, 1987[1]).

Technology education at the K-12 and post-secondary levels should be the venue for on-going conversations about the diverse, yet infinite quest for "truth, beauty and love" within the very real limits of "Spaceship Earth." No other part of our educational system so personally and explicitly connects individual values and actions with social and ecological consequences. With convincing authenticity rooted in its combination of theory and praxis, technology education could provide the critical forum for developing a much-needed 21st-century "technological integrity." Integrity, after all, is what artists and parents as well as engineers and architects want in their progeny.

Technology is one of the premier ways in which humans impress their ideas and values, their *Weltanschauung*, on the world at large, both the natural and the social worlds. Through technology, humans constantly remake the natural environment and human interactions in response to their ideas of what is "truth,

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[1]It is worth noting here that I use the term "technology" with the all of the varied meanings that Carl Mitcham has identified: material objects, knowledge, process, and volition. Rather than identify each usage meaning, I will rely on the reader to apply the proper meaning given the word's context. It will be obvious that I have been heavily influenced by Mitcham, 1994. I only discovered S. Chandrasekhar's <u>Truth and Beauty: Aesthetics and Motivations in Science</u> while preparing this manuscript for publication, some five months after the original presentation. An astrophysicist and Nobel laureate, Chandrasekhar employs biographies of scientists in a series of lectures exploring the relationship between scientists' search for beauty and their conceptions of truth.

beauty and love.” In the United States, technological concerns have, in Neil Postman's words, transformed culture into a “technopoly” where we draw our frames of reference and symbols from the technological realm and spend an inordinate amount of time trying to cope with technological issues rather than employing technology to cope with human issues (Postman, 1992).

Like it or not, this situation makes it all the more important that we all become more literate in the symbolism of technology, more expansive in our perspectives on technology, and more creative as well as critical in our reflections on technology (Schuurman, 1995). This is precisely why students should be learning technology, so that they can participate in these conversations, creating and contributing their own visions of truth, beauty and love. To paraphrase what Samuel C. Florman has written regarding engineering, “although [technology] relies upon science and mathematical verities, in the end it responds to the demands of the human spirit” (Florman, 1996, p. 35; see also Chandrasekhar, 1987).

As Karen Zuga's recent review of the literature make clear, technology educators are overwhelmingly concerned with the *what and how*—the means of the curriculum—rather than with the rationales for having a curriculum at all, the *why* learn (Zuga, 1994). We need more debate on goals than criteria; less how and more why; less on skills and more on attitudes; less on techniques and more on relationships between technology and human values and goals. We need to focus more attention on ends rather than means, for in discussions of ends we will frame the necessary contexts for means.

Here, I would like to address, in suggestive rather than definitive terms, several issues that can contribute to a flourishing of technology education. First, this essay assesses currently popular rationales for technology education. Second, it expresses the conviction that technology, like any part of a formal curriculum, should contribute not just to students' skill and knowledge but also to their capacity to develop moral perspectives and social wisdom. Third, it sketches the relevance of the contention that technology is more akin to art than it is to science and mathematics as a powerful “way of knowing.” Fourth, the essay illustrates the importance of linking technology education to changes in social and economic structures. Finally, I suggest that broad social support for technology education will come only when educators see their mission as providing learners with opportunities to develop a personal sense of technological integrity.

Reviewing Rationales

Nearly all discussions of motivations for learning technology have been directed at decision-makers, not students. Most of the investigations have been about why educational administrators should require students to study technology, not about why students might be enthusiastic about learning technology (Technology Education Advisory Council, 1988; Savage and Sterry, 1990; *Camelback Symposium*, 1992).[1]

My reading of the literature suggests five basic categories of rationales for studying technology, each of which is, I am afraid, logically or historically flawed.

First, personal utilitarianism: kids need to learn technology to get and hold a job. How do we know this? Well, employers and the government tell us. Do they? We can all cite various studies that indicate a lack of technological capabilities among today's students, be they in high school or college. Among the most potent is, of course, *What Work Requires of Schools: A SCANS Report for America 2000*, U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills (1991), or SCANS report (see also Boyett and Conn, 1992). Still, we should be careful of concluding that employment needs support technology education.

A recent survey of the CEOs of "Fortune 500" firms shows that "math, science, technical and computer skills" were mentioned less frequently than analytical and conceptual problem-solving skills and "higher-level proficiencies in writing and reading, along with effective individual and group communications skills." A lack of technical competency was not even mentioned in a list of student deficiencies that included the inability to diagnose and solve problems, a lack of initiative, the inability to apply their skills to new and unfamiliar problems, and the inability to work effectively in groups (Nidds and McGerald, 1995, pp. 27-28). Much the same is reported for college graduates. *Higher Education and Work Readiness*, the report from the American Council on Education's Business-Higher Education Forum, concludes:

> Corporate leaders agree that graduates are deficient in a number of areas, including leadership and communication skills; quantification skills, interpersonal relations, and the ability to work in teams; the understanding needed to work with a diverse work force at home and abroad; and the capacity to adapt to rapid change (1995, p. 3).[2]

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[1]I am referring here to a large, heterogenous literature produced by the International Technology Education Association, including the association's journal, *The Technology Teacher*. Interestingly, however, of the 82 responses given by teachers, teacher educators, supervisors and suppliers at a workshop held by the Technology for All Americans Project at the ITEA Conference in Nashville, March 28, 1995, only 6 explicitly mention competitiveness and 3 directly note employment opportunities. Much more commonly noted are generalizable thinking skills and aptitudes and a commitment to the students' moral right to access of knowledge. R. E. Satchwell (personal communication to The Technology for All Americans Project Writing Team, April 4, 1995).

[2]Specifically, notes one CEO: "Technological skills appear to be getting better, but I think deficiencies in composition, reading, writing, logic, and clarity of thought processes are becoming more pronounced." (p. 12).

And before you object, “But our students learn these skills in technology education,” I have to point out that none of these capabilities are unique to technology education, nor are they traditionally associated with technical disciplines,[1] and most can be developed conveniently as part of a project-based, integrated curriculum that does not include technology (Florman, 1996, Chapter 8).

At the very least, we have to recognize that technological literacy, absent these other skills, will not necessarily increase the employability of our students. More importantly, we have to recognize that this simply has not proven to be a very powerful argument in favor of technology education. Parents and decision-makers have not flocked to technology education, as opposed to, say, school-to-work programs, in an effort to prepare the next generation for its challenges and opportunities.

Second, national utilitarianism: the nation only progresses to the extent its citizenry is prepared to contribute to and benefit from technology. In fact, relatively few individuals have materially initiated basic technological changes and history suggests that factors like cost of capital, governmental incentives for invention, and cultural support of innovativeness are greater influences on prosperity and growth than are workforce competencies (Mokyr, 1990; Rosenberg and Birdzell, 1986). This has certainly proven the case in the industrial development of nations such as Japan, Taiwan, and India, where technological elites have propelled change in the past century.

Especially in times of rapid socio-technological change (say the eras 1820-1860, 1890-1910, and 1980-2010 in the United States) work force skills commonly lag behind leading-edge and even “best practice” technologies. In each era, innovative educational programs have had to be introduced to assist the workers in catching up (Rosenberg, 1976, pp. 197-200; Stevens, 1995).[2] The argument that technological literacy is critical to technological progress is not persuasive largely because it is not historically true.

Third, national security: it's a competitive, global marketplace; either we win or we lose. The United States is in a fierce economic war with other nations that we will win or lose depending on our technological capabilities. Actually, international economics is not a zero-sum game; technology is only one of many influential factors; and national employment is as affected by credit and

[1]See Florman (1994), Chapter 8, “Faults and Foibles,” for a discussion of the limiting effects of an engineering perspective on the ability to work with others, communicate, and be persuasive. I am reminded of a comment made by then-Attorney General Ramsey Clark at a public address at Stanford University in 1968 or 1969 that “law school sharpens the mind by narrowing it.”

[2]I consider these to be America's three industrial revolutions. These eras are associated with, in sequence, the growth of the public school system and technical associations; the definition of a new, discipline-based curriculum, trade schools, and secondary schools; and the current calls for educational reforms based on “constructivism,” “authentic learning,” “project-based, integrated curriculum” to replace the discipline-based curriculum that has dominated the twentieth century. These are the dominant educational responses to the three industrial revolutions that have shaped the modern economy and society.

monetary policy as it is by international competition for certain types of jobs (Krugman, 1996).

Additionally, many companies are coming to learn that cooperation is an important element within the competitive system. Technologies and their interactions with social, ecological and economic factors as well as with other technical systems have become so complex and so interrelated that companies, industries and nations now have to cooperate on many issues. Coalitions, partnerships and collaborations all require shared assumptions and an ability to communicate, even while different agendas are pursued. A group executives of multi-national auto companies recently concluded that “To be More Competitive, Competitors Feel They Must Cooperate” (Kurtz, 1996).

Further, in this global system, where cultures and languages separate people, technology is a potentially powerful cohesive element. Because technologies are potent systems of symbols, it is potentially an effective form of communication. People who cannot speak one another's language can—indeed, must—exchange, understand, and learn from one another's technological designs and systems. Focusing on individual and national competitiveness is not, in the long run, conducive to motivating learning or promoting achievement. Nor is competition a particularly effective frame of reference for working with people in the many countries where issues of appropriate scale, environmentally non-invasive technologies, and collaboration with indigenous cultures and technological traditions are far more pertinent than considerations of international trade.

Fourth, an enlightened populace that is technologically literate will make better technological decisions (Brennan, 1995). This, of course, rests on the presupposition that technology is somehow democratically determined and controlled. This reflects a broad and welcome faith in the democratic process but a naive understanding of the processes of technological choice. First, our experience does not show that even broadly held knowledge on the part of the electorate will provide good decisions in the political sphere (Wenk, 1989). Second, it has been issues of privilege and power, not knowledge and understanding, that explain the unwillingness of American businesses to accept even the minimal type of civic regulation of health, safety and environmental issues by that has been legislated since the 1960s and more recently dismantled. Similarly, it is control of the workplace and preservation of “management prerogatives” that underlay business rejection of the “Technology Bill of Rights” proposed by the International Association of Machinists and Aerospace Workers in 1981 (Shaiken, 1984, Chapter 8). In other words, technological knowledge itself is not enough; what is critical are the goals, values and principles to which the knowledge is put.

Fifth, technology is a pre-eminent example of applied problem-solving. Ironically, problem solving—the buzz-word rationale that may be one of the most potent in terms of persuasiveness within the educational community—may also be one of the most problematic. Permeating contemporary discussions about technology is a negativity that denies what most inventors and designers feel: the exhilaration of technology in action, the sheer joy of creating something that does what is supposed to do.

If the generic benefit of technology is problem solving, it sets up a perspective of life as a set of problems; it establishes a psychology that is negative rather than optimistic and potentially feeds youthful cynicism and alienation. Further, it implies that technology can solve all kinds of problems—still we know that technology by itself cannot solve problems of war, famine, racism. Problem solving “techniques”—note the word—too often ignore the cultural, the political, the economic, the irrational. To concentrate on “problem solving” de-emphasizes the human interactions and social processes of defining wants and satisfying needs, and promotes the notion that technology directly leads to human benefits. In other words, we confuse technological progress (problem solving) with human progress (Postman 1992).

Each of these five rationales asserts a crassly economic/utilitarian motive for education and assumes that such rationales are motivating to others. Additionally, these are generally presented as external motivations and, as educators know, emphasizing external motivation diminishes the internal motivation for trying and mastering anything. At their root, these rationales are rooted in a technocratic view of the world. We need a new set of rationales that can only be built upon a different set of assumptions about how the world works.

Technology and Values

Technology educators too often posit education as a mechanical system and suggest that once the pedagogical mechanism is consistently fueled with domains of knowledge and process, the administration will turn the key, and the machine will run. Unfortunately, this engine lacks a spark. Technology education will only gain its place on the educational agenda when its proponents make a moral commitment to human good, to love, in other words, and produce curricula that address that vision.

Here, I think the experience of informal science and technology centers is instructive. Riding the wave of public interest in the space program and environmental issues, science and technology centers sprang up in numerous metropolitan areas in the 1960s and 70s. These educational organizations focused on hands-on, participatory experiences that demonstrated scientific principles and technological processes. Technology centers were created and existing ones expanded at an exponential rate, funding was lavish, and their visitation increased dramatically.

Then an interesting thing happened. Attendance stagnated; funding became harder to find; the profession had an identity crisis, and started assessing its programs. The public, which had turned to the participatory nature of sci-tech centers after being turned off by the “Do Not Touch” signs in art and history museums, rather quickly got tired of hands-on “bells and whistles.” Ultimately, the gadgets were technically elegant but sterile and unmotivating; they were unconnected to real life, real people, real challenges, real opportunities, real learning, and personal meaning. The IMAX theater, now in 3-D, a storytelling, indeed myth-making medium of awesome imagery and larger-than-life proportions, has become the sci-tech centers' biggest audience draw.

The lesson is that you have to integrate human choices, authentic ambiguities and personal passions with technical virtuosity in order to hold onto the learner who has other options. Descartes' error, as Antonio R. Damasio has argued, was in trying to separate emotion from intellect. We should know better. We need to acknowledge that issues of self-esteem, motivation, feelings—our emotions—are part of the learning process; we recognize that without humanity and values there can be no true learning, no development of wisdom (Damasio, 1994; Goleman, 1995; Perkins, 1995, Chapter 7). Passion for "truth, beauty and love" is at the heart of this enterprise.

Caught in its own technocratic world view, the profession has failed to assert a clear and shared view of the key elements of a technological value system. The ultimate goal of education must be a more just, equal, and participatory society, not just more technically proficient individuals. The moral imperative of (technology) education is to promote the capability of people to be engaged, influential, thinking/doing beings. This means that people must be able to criticize and challenge as well as create and cope. It means that value-laden terms like "appropriate technology" and "sustainable design" must be at the heart, not the periphery, of teaching and learning. These issues are essential to a 21st century education that contributes to "the formation of habits of judgement and the development of character, the elevation of standards, the facilitation of understanding, the development of taste and discrimination, the stimulation of curiosity and wondering, the fostering of style and a sense of beauty, the growth of a thirst for new ideas and visions of the yet unknown" (Israel Sheffler quoted in Bracey, 1996, p. 11).

A compelling ethical vision, I submit, will rest heavily on the antithesis of the language commonly used in technology education. It will offer a better balance and interplay between values and skills, artistry and instrumentality; discipline and creativity, production and contribution; competitiveness and collaboration; standardization and multiplicity; problem solving and opportunity generating; natural and human-made; tradition and innovation. An effective rationale for learning technology would illustrate how technology is a fundamental human expression of the diverse forms of our individual and collective constructions of "truth, beauty, and love" (Florman, 1976, p. 150; Chandrasekhar, 1987).[1]

This is not to argue that technology educators should necessarily teach a specific moral code. It is an observation that many technology educators already share an implicit set of values that they seldom explicitly recognize or reflect on and thus inadvertently pass on to their students. This value system is largely technocratic and positivistic in character. The position being advanced here is that technology education will be truly socially beneficial and valued when it is more balanced and worldly, and includes explicit discussion of technological

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[1]Florman (1976), p. 150, eloquently argues that "to seek love, pleasure, wisdom, and beauty without having the solid roots in life which one achieves only by constructive activity, is to cast oneself adrift in the empty space of aimlessness [emphasis in the original]." I take his argument to apply to the general population as well as the professional engineers to whom the book is ostensibly directed.

values so that students can reflect and develop their own ethical standards. What is truly critical is not what we value in technology, but what values we express through technology.

In two major books, the eminent educator Ernest L. Boyer has called for technology education so that elementary students “recognize the value and dignity of work, distinguish wants from needs, and understand the importance of becoming creative producers, informed consumers, and responsible conservers,” while high school students should “develop the capacity to make responsible judgements about [technology's] use” (Boyer, 1995, p. 99; Boyer, 1981, p. 111). Stated thusly, few will dispute the goals; however, the devil, as they say, is in the details.

Thus, technology education ought to be centered on a love for human beings and “Spaceship Earth,” not merely on the effort to extend human capabilities and their domination over nature. Herbert Read, the great scholar of industrial design, implores:

> Only a people serving an apprenticeship to nature can be trusted with machines. Only such people will so contrive and control those machines that their products are an enhancement of biological needs, and not a denial of them (Read quoted in Sale, 1995, p. 212).

Technology education will only gain widespread public support when the profession explicitly develops particular “habits of mind,” ways of thinking that consistently respect the environment, promote human welfare, support justice between peoples through, as well as in spite of, technology (McDonough, 1995).[1] As the social critic Paul Goodman has suggested, “Whether or not it draws on scientific research, technology is a branch of moral philosophy, not of science” (Epigram in Postman, 1992).

Technology as Art

I think Ralph Waldo Emerson was aiming at something like this when he acknowledged that wisdom is revealed in many endeavors. In 1870, Emerson, hardly an apologist for technology, wrote:

> Raphael paints wisdom; Handel sings it, Phidias carves it, Shakespeare writes it, Wren builds it, Columbus sails it, Luther preaches it, Washington arms it, Watt mechanizes it (Emerson, 1870, p. 47).

It is not surprising that Emerson's list includes the embodiment of wisdom[2]—in short, the ability to judiciously apply experience and knowledge—

[1]McDonough, Dean of the School of Architecture at the University of Virginia, proposes a set of design protocols that includes cost, performance, aesthetics, ecology, and “social justice.” Using a type of “design filter,” students in McDonough's “Institute of Sustainable Design” will consider a wide range of issues relating to how people create, produce and interact with material culture and mechanical systems.

[2]The New Shorter Oxford English Dictionary (Oxford, Eng.: Oxford University Press, 1993), s.v. “wisdom,” defines wisdom as “the quality of being wise, esp. in relation to

in the fine and practical arts as well as the more commonly recognized areas of religion and literature. Daedalus, in Greek legend the personification of the mechanical arts, was the patron of both the artists' and the craftsmen's guilds. Nicholas Negroponte, founder of the Media Lab at the Massachusetts Institute of Technology, reports that “[t]he traditional kinship between mathematics and music is manifested strikingly in contemporary computer science and within the hacker community” (Negroponte, 1995, p. 222). It was commonly acknowledged in the nineteenth century that art and technology had much in common: “In fact,” wrote one nineteenth-century chronicler of engineering, “observation frequently shows, that the power of constructing poetry and machines are united in the same individual” (Howe, 1840, p. 391; Ferguson, 1992; Hindle, 1981). In other words, beauty and technology are intimately linked as expressions of human values and humane wisdom.

The point is that learning technology can be effectively promoted for the same reasons that arts education is promoted; namely that technology, like art, is a way of learning and knowing, of seeking “truth, beauty and love.” Remember, arts educators succeeded where technology educators failed, in getting the arts officially included “into the pantheon of the “basic” school curriculum,” the Goals 2000 legislation. In language that should be second-nature to technology educators, arts educator Scott T. Massey proposes that the arts represent a powerful form of symbolic communication, like numbers and languages; employ non-linear forms of thinking and problem-solving; and engage people in multi-sensory activities employing multiple intelligences. All of these rationales apply to studying technology (Massey, 1995, p. 5).

Massey goes on to argue that arts education provides generic aptitudes “centered in design, communication, and learning” (Massey, 1995, p. 6). Consider how closely this description of the artistic process parallels the technological process if only we substitute a few words: “playfully responding to stimuli through aesthetic [technical] sensibilities; transforming and organizing these responses into rich, multi-sensory inner imagery; expressing the imagery through an artistic [technological] work; and evaluating the artistic expression [social and ecological impact] throughout” (Scheinfeld and Steele, 1995, p. 23). It is no wonder Rube Goldberg-inspired activities are so popular among teachers and learners! Students can learn through the arts much of what we want them to learn to learn through technology, and vice versa. We would do well to consider more systematically and promote more seriously the affinities between technology and art as ways of learning .[1]

Technology as History

Finally, a persuasive argument for technology education can be made by acknowledging the course of historical change. This argument would have to be based on a broad sense of the history of learning technology and about the importance of history. A historical perspective will suggest why learning technology is not just different from but fundamentally unrelated to earlier arguments for learning manual or industrial arts or industrial technologies (Colelli, 1993; Foster, 1995; Barella and Wright, 1981).

This country is in the midst of its third industrial revolution. The first was mechanical and local in scope; the second was scientific and national; this one is electronic and global. Education has had a different role to play in each of those transformations.

The first industrial revolution was based on steam engines, machinery and the factory system. It relied little on science or book learning. Tinkerers, talented mechanics, practical problem-solvers, and entrepreneurial dreamers made the great contributions. Knowledge about how to do things—on the farm or in the factory—continued to come from traditional "know-how" or "on the job" learning. In 1845, well before the Morrill Act Federal Land Grant Act of 1862, the educator Horace Mann concluded that Americans were "a mechanical people" (Siracusa, 1979). This broad mechanical aptitude had everything to do with everyday experience, not formal education, and Mann's educational reforms for public schools did little to directly change the situation. However, the nearly 100 mechanics' institutes founded between 1818 and 1850 and the innumerable lyceums, libraries, and lectures aimed at mechanics, artisans, and other skilled working people did make available opportunities to link learning and producing (Stevens, 1995).

The second industrial revolution was based on knowledge of the physical world that simply did not exist fifty years earlier. Electricity, chemistry and steel production became the catalysts of change. The goal of production shifted from individual to mass consumption and the ideal production process was transformed from the batch system to flow: electricity flowed, chemical processes flowed, livestock slaughtering flowed, and the assembly line flowed. A new conception of the relationship between humans and technology was enunciated by Frederick Winslow Taylor, a relationship that trumpeted the primacy of "the system" and the system was "mass production."

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conduct and the choice of means and ends; the combination of experience and knowledge with the ability to apply them judiciously." Surely this is what we mean, in general, when we talk about technological literacy.

[1]Directing our attention to the connections between technology and art may have important consequences for issues of gender equity, at least insofar as cultural assumptions and perceptions of art and technology can be altered.

There was a paradoxical relationship of formal education to productivity under mass production. On the one hand, the new engines of change were increasingly operated by highly trained engineers and managers based on scientific knowledge developed in research laboratories staffed by university educated researchers. On the other hand, education became more and more peripheral to the needs of masses of industrial workers. Assembly-line jobs were designed so that “any idiot” could perform the job. A basic high school education was all that was needed. In this context, industrial arts (almost exclusively taught in grades 6-12) served as a basic introduction to materials and machinery for (almost exclusively male) students whose adult occupation might or might not directly rely on technological skills.

The third, and current, industrial revolution is based on the integrated circuit, powerful new methods and applications of information processing, and intensified environmental pressures. This revolution is based on continuous change and fundamentally new ways of thinking about productive activity: from careers in an industry to jobs in various industries; from hands-on to hands-off production; from generic to customized products; from repetitious labor to novel work tasks; from bureaucratic control to team-oriented work; from more to better as an indication of quality; from disposal to re-use or recycle as the end of the product development process; from extractive to sustainable production.

The implications for education are enormous and it is those implications that we struggle with now. What we do know is that this work and education for work are qualitatively different from what any previous generation has known:

> The great majority of the new jobs require qualifications the industrial worker does not possess and is poorly equipped to acquire. They require a good deal of formal education and the ability to acquire and to apply theoretical and analytical knowledge. They require a different approach to work and a different mind-set. Above all, they require a habit of continuous learning…. At the very least [workers] have to change their basic attitudes, values, and beliefs (Drucker, 1994, p. 62).[1]

Technology educators, regardless of their organizational lineage, have to articulate a vision that is, in fact, divorced from the industrial arts background. The fundamental questions have to do with how different generations of Americans have met their needs for understanding technology through formal and informal means. The relationships between technology education and its industrial arts antecedents within the formal educational community are but a small part of this. Where Americans once learned technological attitudes and aptitudes from direct daily experience, they now learn from the media, informal learning centers, and on-the-job training. Technology educators will be better

[1]Drucker (1994). This essay, along with Postman, 1992, Carnevale, 1991, and Marshall and Tucker, 1992, should be required reading for all technology educators who are interested in both the development of employment skills and the liberating aspects of technology education.

served by coming to grips with their unique role in this broad context rather than by examining narrow organizational or intellectual lineages.

A broader and truer sense of the history of technological knowledge beyond the realm of formal education will go far to aid our understanding of the need and role of technology education in the future (Pannabecker, 1995). This means explicitly learning from historical examples of the processes of inventing, designing, utilizing, and assessing technology. It means employing what we learn from experience and tradition in our present circumstances so that we can continue to learn.

Technological Integrity

Studs Terkel's latest book, *Coming of Age*, is made up of reminiscences of people who have lived through much of the 20th century. Terkel points out that technology has had much to do with the fact that so many people now live into and past their 70s. He also points out how much technology is on the minds of people reviewing their lives in this century:

> It is not technology per se that the grayheads in these pages challenge, though there are a couple of Luddites in the crowd. It is the purpose toward which it has so often been put. Among the grievances aired: the promiscuous use of the machine; the loss of the personal touch; the vanishing skills of the hand; the competitive edge rather than the cooperative center; the corporate credo as all-encompassing truth; the sound bite as instant wisdom; trivia as substance; and the denigration of language (Terkel, 1995, p. xiv).

If we want the reminiscences at the end of the 21st century to convey a different technological experience, we need to create a new, reflective (not reflexive) attitude toward technology. Vos Savant is correct in that the hiccups are an involuntary spasm in a biological system; technology is all about human values and volition.

To provide leadership and elicit commitment requires not primarily an intellectual agenda, the definition of a discipline, or a standardized curriculum, but a compelling vision of the future. To end racism and ensure civil rights, to create "The Great Society," to put a man on the moon and return him safely to earth—those movements attracted massive support because they appealed to Americans' "better angels," in Abraham Lincoln's memorable phrase. They specifically drew on the pursuit of "life, liberty and happiness" ("truth, beauty and love"?) and "America's traditions of ingenuity, resourcefulness and innovation."[1]

Learning technology is essential precisely because it situates learners as participants in the process, provides them with real contexts for their actions,

[1]The latter phrase is drawn from the mission statement of my place of employment, which reads: "Henry Ford Museum & Greenfield Village provides unique educational experiences based on authentic objects, stories, and lives from America's traditions of ingenuity, resourcefulness, and innovation. Our purpose is to inspire people to learn from these traditions to help shape a better future."

and requires them to reflect about the process, the product and the impacts (Technology for All Americans Project, 1996). Technology education is the primary opportunity for students to systematically and developmentally engage technology as knowledge and process—acquiring concepts and reflecting on laboratory activities. They gain experience assessing the impact of technology as artifact and volition in real world contexts—experiencing first-hand their material surroundings and examining actual social and ecological results. It is the one opportunity young people have to develop technological confidence yet cautiousness, ambition tempered by humility (Postman, 1995, p. 122).

The mission facing technology educators now is to educate the first generation of the 21st century to be neither technocrats nor techno-peasants, neither technophobes nor technophiles; to neither fear technology nor to place undue faith in it; to bridge, in other words, C. P. Snow's "two cultures" (Snow, 1993). As an integrative way of thinking and acting, "technological integrity" expands the meanings of "a new basic" by concentrating on principled action rather than technical efficiency. Helpfully, it shifts the profession's reliance away from the concept of "technological literacy," which has been irretrievably adopted by the public and the U.S. Department of Education to refer specifically to educational technology, computer-based skills, and Information Age capabilities (U.S. Department of Education, 1996). Technological integrity implies the development of values and ethics as well as the mastery of concepts and skills. By fostering a sense of technological integrity, technology educators will contribute to their students' capacity to deal holistically with their natural, social, and technological environments. The 21st century will demand no less.

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Articles

Classifying Approaches to and Philosophies of Elementary-School Technology Education

Patrick N. Foster

In 1974, Hoots classified historical philosophies of elementary-school industrial arts (ESIA) into four categories: *subject matter*, in which children would study technology and its social impacts (e.g., Gilbert, 1966); *arts and crafts*, consisting of what Hoots (1974) called “concrete manipulative activities” (p. 225); *method of teaching*, in which industrial arts delivered, reinforced, and enriched the traditional elementary curriculum (e.g., Henak, 1973), and *tools, materials, and processes*, focusing, as the name implies, on technological materials and processes (e.g., Miller & Boyd, 1970).

Although practioners probably employed a combination of some or all of these, the primary debate among theoreticians at the time was whether elementary-school industrial arts should be promoted as a method of teaching or a subject matter. The liveliness of this debate notwithstanding, by the time Hoots’ paper was published, the ESIA movement was in a decline it was not to recover from for nearly twenty years.

Context

The past few years have seen a steady increase in interest in elementary-school technology education (ESTE). This is in part evidenced by an increase in publications and conference presentations on the topic (Pagliari & Foster, 1995). Furthermore, the quality of these publications and presentations may signal a move toward a more sophisticated view of ESTE than that of the 1980s and early 1990s. Still, there has yet to be much scholarly discussion on the variety of approaches and philosophies technology educators may advocate as the profession once again seems poised to make elementary education a priority.

The last period in which this much attention has been paid by the field to its elementary-school program was arguably the years 1962-1974. That period saw the development of the Technology for Children (T4C) program (“Industrial Arts For,” 1966; Dreves, 1975) and the Technology Exploratorium (Heasley, 1974; n.d.); books by Gilbert (1966), Kirkwood (1968), Scobey (1968), and Gerbacht and Babcock (1969); and a yearbook on ESIA (Thrower & Weber, 1974) published by the American Council on Industrial Arts Teacher Education.

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Also during this time period, the American Council for Elementary-School Industrial Arts was formed (Miller, 1979), and a National Conference for Elementary School Industrial Arts was held in Greenville, NC. Participants of that conference developed this "Definition of Elementary School Industrial Arts:"

> Industrial arts at the elementary school level is an essential part of the education of every child. It deals with ways in which man thinks about and applies scientific theory and principles to change his physical environment to meet his aesthetic and utilitarian needs. It provides opportunities for developing concepts through concrete experiences which include manipulation of materials, tools and processes, and other methods of discovery. It includes knowledge about technology and its processes, personal development of psychomotor skills and attitudes and understandings of how technology influences society. (Hoots, 1971, p. 3)

As is clear from this lengthy definition, there was a fair amount of debate as to the purposes of industrial arts for elementary-school children. In fact, ESIA is not really defined here—this "definition" could be more aptly considered an "enumeration of contributions" industrial arts was thought to make to the education of children. The gravity of the content–method debate was evident in this position statement, which, for example, noted that industrial arts should (a) "deal with" technological change, although how this was to be accomplished was not immediately specified; (b) provide "opportunities for developing concepts through concrete experiences," although whether these were concepts related to the school curriculum, to industry and technology, or to both, was not explained; and (c) include "knowledge about technology" without specifying a method. In discussing the elementary level, LaPorte (1993) noted that to some extent, "the argument of whether industrial arts should be taught as content or method…continues today" (p. 9).

Purpose of the Study

The profession should be aware of the variety of philosophies and approaches to ESTE accepted by practitioners and theorists. This could allow—and might perhaps instigate—meaningful debate, enabling professionals with diverse conceptions of the field to work together toward common goals. The alternative may be for ESTE to experience the impasse faced by advocates of ESIA two decades ago.

In this study, *philosophy of elementary-school technology education* was regarded as an individual's belief as to the ideal role of technology education in the elementary school. The term *approach to elementary-school technology education* referred to an individual's opinion as to the most appropriate manner of implementing ESTE. The distinction is subtle but necessary; an educator's philosophy should influence his or her approach. In this sense, *approach* may in some cases be the practical manifestation of a philosophy.

The purpose of this study was to identify and classify prevailing philosophies of and approaches to elementary-school technology education. Specifically, the study sought to address two research questions:

1. What classification of philosophies of ESTE is ascertainable from the recent literature?
2. What classification of approaches to ESTE can be identified from existing data on the opinions of leaders in the field?

Methodology

Classification of Philosophies of ESTE

To perform the classification of philosophies of ESTE required the review and analysis of recent literature. Three literature selection criteria were established. Literature considered pertinent was (1) published since 1985, when the American Industrial Arts Association changed its name to the International Technology Education Association (ITEA); (2) widely disseminated; and (3) that in which authors stated or implied a philosophical position on ESTE which specified (1) a rationale for ESTE or (2) a position on the nature of the ideal ends of ESTE, or both (see Kneller, 1964, p. 30-31).

Items of literature were initially classified with others that advocated or reflected similar rationales for ESTE. Next, items were classified with others that advocated or supported similar ideal outcomes for ESTE. These categorization schemes yielded similar results—in other words, items of literature supporting similar rationales for ESTE were very likely to support similar outcomes for ESTE.

In the final classification, characteristics were identified which might further differentiate between the categories. These were characteristics found in many, but not all, items under analysis. They were (1) nature of contribution of ESTE to the elementary school; the (2) role and (3) identity of subject matter; and (4) the nature of teaching methods advocated. Finally, examples were selected from the literature which seemed to exemplify the philosophies.

Classification of Approaches to ESTE

The classification of approaches to ESTE was accomplished by an ex post facto cluster analysis of data collected to identify the opinions of leaders in the technology education field regarding approaches to technology education. In a prior study (Foster & Wright, 1996[1]), 131 leaders were asked to identify appropriate approaches to technology education at the elementary, middle-school, and high-school levels. Thus the data used in the present study was collected for the purposes of investigating approaches to technology education at all grade levels—not just ESTE. Nonetheless, it was clear that the elementary data could be extracted and that this existing information would be useful in addressing Research Question 2.

[1]Please refer to this article for a further discussion of the participants and procedure of the original study. Due to the very small number of leaders in ESTE, and since ESTE is being advocated as an important part of technology education as a whole, leaders in all phases of technology education (K–12 and postsecondary) were selected for this study.

Participants in the original study represented leaders among teachers, supervisors, and teacher educators. Of the 131 respondents, 123 provided opinions relative to ESTE. The data from these subjects was analyzed as part of the study at hand.

Participants were presented with a list of twelve approaches to technology education (see Table 1) and asked to select and rank the three they regarded as most appropriate at the elementary level. Two respondents employed a "fill-in" option also presented on the instrument.

Table 1
Items on survey instrument

A. applied/practical science	E. design/problem solving	I. modular approach
B. career emphasis	F. engineering systems	J. socio-cultural approach
C. constructive methodology	G. extra- or non-curricular activities	K. student-centered approach
D. computer emphasis	H. math/science/technol.	L. tech prep

Data analysis. Each participant's first choice of approach to ESTE was assigned a score of "3;" second choices were scored "2;" third choices "1." All items not selected were scored "0;" thus each of the thirteen items (twelve pre-identified approaches and one write-in) was assigned a score by each participant. Because this data was not continuous, the appropriate quantitative classification procedure was cluster analysis, "a multivariate statistical procedure that starts with a data set containing information about a sample of entities and attempts to reorganize these entities into relatively homogeneous groups" (Aldenderfer & Blashfield, 1984, p. 7).

The analysis was performed with SPSS version 6.1.1 for the PowerPC. Given the exploratory nature of this cluster analysis, several variations of each available clustering method (Ward's, between- and within-groups average linkage, furthest neighbor, nearest neighbor, centroid, and median) were run.

The final solution set was obtained via Ward's method. This set, which consisted of solutions ranging from two to five clusters, was the most interpretable. Ward's method produces clusters which are easily distinguished from other clusters and which tend to be tightly packed (Aldenderfer & Blashfield, 1984). Squared Euclidean distance, which is sensitive to both shape and magnitude, was chosen as a measure. When the data was subjected to the same cluster analysis with Euclidean distance substituted for squared Euclidean distance, the same solution set was obtained. Standardized scores (z-scores) were used because the wide variation in item scores was causing high-scoring items not to cluster when raw scores were used.

Results

Research Question 1: What classification of philosophies of ESTE is ascertainable from the recent literature?

Three philosophies of ESTE were evident from the literature. They were labeled *content*, *process*, and *method*.

Technology education as content. Proponents of the *content* philosophy see ESTE primarily as providing students with knowledge about technology. To these writers, technology (or alternately, technology education) is a discipline. Not all examples of literature supporting the view of ESTE as content identified the same content structure. One frequently cited structure was DeVore's (1980) three-dimensional matrix representing technological endeavors (communication, transportation and production), technological resources (tools, machines, etc.) and cultural contexts (prehistoric, craft era, mechanization, etc.).

The DeVorian view is clear in *Teaching Technology to Children* (Minton and Minton, 1987), a book intended for pre-service elementary schoolteachers. ESTE is viewed as having its own content; indeed, technology is defined as "technical *knowledge*" (p. 4; italics added), divided into DeVore's (1980) content areas of production, communication, and transportation. Peterson (1986) also applied the DeVorian content formula to the elementary program.

Kieft (1988) summarized the view that although ESTE was to be integrated with other subjects, it involved certain content of its own—content organized per the popular Jackson's Mill curriculum (Snyder & Hales, n.d.). He described ESTE as taking the form "of units of study with activities to introduce, reinforce, or clarify some of the technology concepts…The content usually focuses on an aspect of transportation, communication, manufacturing, construction, or energy" (p. 29).

Thode's (e.g., 1989, 1996) works also represent the *content* philosophy, although they do not rely upon traditional content structures. "The curriculum must cover the fashionable current technologies as well as basic technologies and the emerging technologies" (Daiber, Litherland, & Thode, 1991, p. 193). To Thode, "technology education is a defined discipline" (1996, p. 7).

Technology education as process. A second philosophy identified in this study regards ESTE as a process or skill which should be taught to children, and which has attendant content related to replicating the process. But the exact identity of the process seems to be in question. Two related but distinct variations of the *process* philosophy are evident in the literature.

In one variation the process being taught is "design." In this conception students design solutions to problems. ESTE is considered "children's engineering" (Dunn & Larson, 1990, p. 37). As a form of engineering, it eventually becomes concerned with the physical sciences and their laws. Todd and Hutchinson (1991) expressed the ideas involved in the conception of ESTE as "design and technology." To them, design and technology was not a separate subject, or even an integrated one—but a "new paradigm" for education itself.

A second variation of the *process* philosophy regards problem solving as the process of technology education. Here, problem solving is a broad skill which should be taught to all children. ESTE is viewed as supporting the larger elementary program—not the larger technology program (Forman & Etchison, 1991; Sittig, 1992).

Advocates of the problem solving variation regard the process of ESTE as more important than the content of the problem being solved; advocates of the design variation view the content of the whole school and of the design processes as primary. This distinction is illustrated in Figure 1 below.

Technology education as method. In the final philosophy, *method*, ESTE "begins with three things in mind. The first and certainly the most important is the child, the second is the elementary school curriculum, and the third is an appropriate technology activity" (Kirkwood, 1992, p. 30). Often, as LaPorte (1993) suggested, the content has an industrial or technological nature. Nevertheless, the content is drawn from the existing elementary curriculum—math, social studies, language, and science—not a technology education curriculum.

As Braukmann (1993) wrote, "enough goals *already* exist in the areas of reading, communication, math, science, and the social studies to fill a curriculum." (p. 23) Even though it might be important to treat the subject of technology separately, he wrote, "little time is left for it" (p. 23). ESTE, in Braukmann's view, does not exist for its own sake; rather, it should support "existing goals in science, math, and communication skills" (p. 23). Supporters of this philosophy are typically as unapologetic about slighting technology content as champions of technology-as-subject-matter are about having to lecture occasionally to deliver that content.

Elements of the philosophies

Figure 1 is a tabular representation of the final classification of philosophies of ESTE evident from the literature. Six characteristics of each philosophy are specified to facilitate comparisons among the philosophies. In addition, an example from the literature is identified for each philosophy. Brief descriptions of the characteristics follow.

Nature of contribution to elementary-school content. Unlike the other identified philosophies, the *method* philosophy does not regard its contribution to the content of the elementary curriculum as necessarily unique. In this view, ESTE is a method for delivering the traditional curriculum. It does not offer unique knowledge. The remaining philosophies regard ESTE as an ideally integrated, yet essentially distingusihable, subject in the curriculum.

Rationale. As a result, the rationales advanced by advocates of the *content* and *process* philosophies point out ESTE's unique aspects. Both rationales imply that the elementary curriculum would be essentially incomplete without technology education.

Nature of ideal outcome. Both variations of the *process* philosophy view specific skills as the ideal outcome of an elementary program of elementary education; in the *content* philosophy, knowledge is the primary outcome. In the *method* philosophy, ESTE is viewed as only one means of helping students acquire the skills and content in question.

Role and identity of subject matter. The literature indicates that design technology has associated and necessary knowledge relating to the process of design, as well as to scientific principles. There seems to be little indication that problem solving, as a conception of ESTE, has unique content directly related to problem solving (although problem solving strategies abound and are occasionally taught to elementary-school students).

Teaching methods. While all of the identified philosophies appear to support hands-on learning, it should be noted that in the *method* philosophy, ESTE *is* a method, and as a term is essentially synonymous with "constructive methodology"—what Bonser and Mossman (1923) referred to as making "changes in the forms of materials to increase their values" (p. 5).

Philosophy of ESTE	**Nature of Contribution to elementary school content**	**Rationale**	**Nature of ideal outcome**	**Role of subject matter**	**Identity of primary subject matter**	**Nature of teaching method(s)**	**Example**
Content	unique	students need to know about technology to understand their world	new knowledge is gained	primary	technology	various; usually including construction, lecture, etc.	Peterson (1986)
Process design	unique	students need transferrable skills to thrive in a technological world	new skills are gained	primary	design processes; whole school	primarily manipulative and/or constructive	Todd & Hutchinson (1991)
problem solving				secondary	(varies)		Sittig (1992)
Method	enrichment	most students learn better by doing	traditional knowledge and skills are reinforced	primary	subjects in the elementary curriculum	constructive	Kirkwood (1992)

Figure 1. Selected characteristics of various philosophies of elementary-school technology education.

Research Question 2: What classification of approaches to ESTE can be identified from the opinions of leaders in the field?

As aforementioned, the solution set consisted of four possible solutions generated via cluster analysis. Since Research Question 1 had already been addressed when these solutions were examined, it was theorized that three basic philosophies of ESTE were evident in the literature. Thus, a three-cluster solution of approaches to ESTE was sought. However, the four-cluster solution (Table 2) was found to be most interpretable.

Table 2
Four-cluster solution classifying approaches to ESTE

Cluster 1: Secondary		Cluster 2: Progressive	
A.	applied/practical science	C.	constructive methodology
B.	career emphasis	J.	socio-cultural approach
G.	extra- or non-curricular activities	K.	student-centered approach
		M.	[write-in item]
L.	tech prep		

Cluster 3: Modern		Cluster 4: Design/Science	
D.	computer emphasis	E.	design/problem solving
I.	modular approach	F.	engineering systems
		H.	math/science/technology

The clusters were output in an arbitrary order. The first cluster, *secondary*, consisted of the four items on the instrument which most clearly illustrated the view regarding elementary-school technology education as appropriately implemented employing traditionally secondary-school means, such as the applied-science view (exemplified on the instrument by the high-school Principles of Technology curriculum), extra- or non-curricular activities, tech-prep, and an emphasis on careers.

The second cluster, *progressive*, seemed to represent the ideals of the founders of industrial arts—the progressives Bonser and Mossman (e.g., 1923)—and later exemplified by Maley (e.g., 1973, 1979) and others. Items in this cluster included constructive methodology, the socio-cultural approach, and the student-centered approach.

The third cluster was labeled *modern*. In contrast to the more traditional *progressive* approach, it was comprised of two items—modular technology education and computer emphasis—which have only recently been advocated in the literature for ESTE. Both items refer to systems of organizing technology education (e.g., Neden, 1990; Hornsby, 1993).

The final cluster, *design/science*, appears representative of the British design and technology movement (e.g., Dunn & Larson, 1990; Williams & Jinks, 1985) and its variants in the U.S. The items comprising this cluster were design/problem solving, engineering-systems approach, and math/science/technology integration.

Discussion

Approaches and Philosophies compared. Although one-to-one correspondence was not identified, there were some strong relationships between certain approaches to and philosophies of ESTE. For example, the *design/science* approach strongly reflected the *process* philosophy while having little in common with either of the other philosophies. This approach subsumed math/science/technology integration, design/problem solving, and engineering systems—which as a whole reflect the philosophy, described above, of ESTE as a process.

The *progressive* approach had a perceptible connection to the *method* philosophy; witness Kirkwood's (1992) aforementioned statement that the hierarchy of concern in ESTE was (1) the child, (2) the curriculum, and (3) the technology activity. Two of the constituent parts of the *progressive* approach were student-centeredness and constructive methodology. The third aspect of the approach, a socio-cultural focus, does not appear to be incompatible with the *method* philosophy, but is not strongly brought out in the literature supporting this philosophy.

Less firm is the relationship between the *modern* approach and the *content* philosophy. The *modern* approach consisted purely of delivery systems—modular and computerized—and from the analysis, no content was implied. Nonetheless, the modular approach in this context itself implies technical content, and further implies that this content is important enough to justify the purchase of modules (see Petrina, 1993). Given Petrina's (e.g., 1993, 1994a) definition of modular technology education, several commercial programs for modular ESTE are available, such as Time-Travelers, a "technology education system designed especially for the elementary level" (Applied Technologies, 1996, p. 1), and the Techno-Train (Bedford Science Supply, n.d.).

The *secondary* approach to ESTE may have some relation to both the *content* and the *method* philosophies, as its constituents include both delivery systems and content areas. While this approach may well reflect a specific philosophy of technology education, it might be suggested that the *secondary* approach shares no special relationship with any philosophy of ESTE found in this study. This approach is supported by very little of the literature reviewed in addressing Research Question 1.

This brings up an important point. Those who wrote the literature exemplifying philosophies, and those whose responses were analyzed here to identify approaches, were not samples of the same population. This is to be expected—theoreticians make philosophies; practitioners take approaches. So those advocating a *secondary* approach to ESTE may simply be advocates of secondary technology education.

Relationship between the findings of this study and Hoots' classification system. Hoots' (1974) aforementioned historical philosophies were discerned from the literature of the preceding semicentury (approximately 1923-1973). This system seems to be an expansion of the more traditional classification of content and method (see Miller, 1979). "The Industrial Arts Issue" (1958) of the

California Journal of Elementary Education referred to two groups of educators with different emphases for ESIA. One group emphasized studying the technical aspects of industry, while another emphasized a more liberal study of technology. Both are content-driven views. The former represents Hoots' "tools, materials, and processes" philosophical category; the latter his "subject matter" category. Together these may be asserted to comprise a single "content" philosophy.

Gerbracht and Babcock (1959), whose arguments that "industrial arts is not another 'subject'" and that "industrial arts justifies its existence on the basis of the help it gives the school" (p. 1) identified them with the *method* philosophy, provided a range of emphases for ESIA. As Hoots (1974) noted, Gerbracht and Babcock epitomized not only the "method" philosophy, but the "arts-and-crafts" as well. Thus these two may be considered as constituents of one larger "method" philosophy.

It is rather straightforward, then, to associate the findings of Research Question 1 with Hoots' historical philosophies. The *content* philosophy of this study subsumes Hoots' "subject matter" and "tools, materials, and processes;" *method* includes his "arts & crafts" and "methodology." There is no analog in his system to the *process* philosophy identified here.

Associating the findings of Research Question 2 with Hoots' categorization was more difficult. This difficulty, however, further demonstrated the lack of parallelism between approaches and philosophies.

To some degree, the *progressive* approach identified in Research Question 2 was similar to Hoots' "methodology," which, he (1974) notes, argues that ESIA's contribution to the school "is in the psychological and sociological areas of child development and in the area of cognitive learning in other subject matter disciplines by providing realistic and concrete experiences related *to those disciplines*" (p. 226; italics added). Further, the *modern* approach to ESTE resembles, to a degree, Hoots' "tools, materials, and processes" philosophical category of ESIA. Hoots' (1974) criticisms of this category echo modern concerns about modular technology education, especially when he discusses the ease with which a teacher can overlook pedagogical concerns and "get into implementation—the actual classroom activities—and end up with a tool- and material-centered [program]" (p. 227).

There seem to be no strong relations between the remaining approaches identified here—*design/science* and *secondary*—and Hoots' categories. Figure 2 is an illustration of the relationships among the three categorization systems.

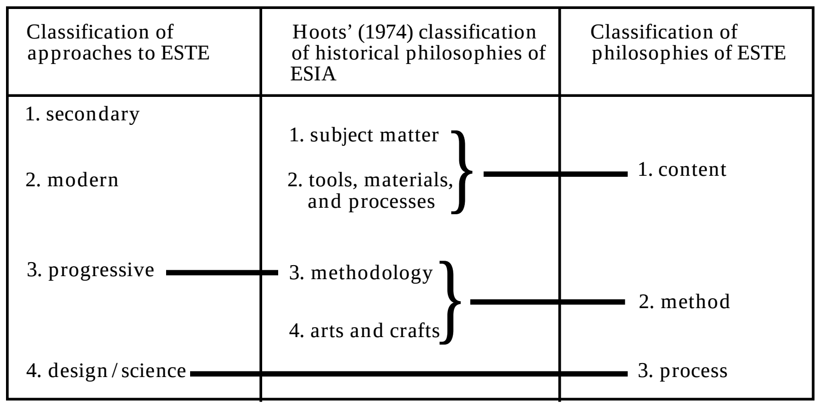

Figure 2. Relationships among the three categorization systems.

Directions for Further Research

In reviewing the literature to address Research Question 1, several articles were found which described ESTE programs or activities. Some of these were rich descriptions of the learning which can take place in the elementary classroom. Few of these articles simply reflected a single philosophy of ESTE. However, upon further inspection, it became clear that many reflected a single approach to ESTE. Hornsby's (1993) description of an ITEA-award winning ESTE program in Kentucky makes it clear that program implementors have taken a *modern* approach; Kirkwood's (1992) approach was *progressive*. An appropriate extension of this research may be to analyze ESTE program-implementation articles in an effort to challenge or validate the results of the cluster analysis described herein.

In a prior study (Foster & Wright, 1996), it was found that technology-education leaders advocated different approaches for ESTE than they did for secondary programs. Nonetheless, research by Zuga (1989), Petrina (1994b), and others who have categorized or discussed categories of curricular approaches and philosophies of technology education, may shed some light on the findings reported here. Further investigation is needed associating approaches to and philosophies of ESTE with their counterparts in secondary technology education.

Final Thoughts

At the 1996 annual conference of the International Technology Education Association, two attendees, presumably secondary-school teachers, were overheard bemoaning the overabundance of elementary sessions in the conference program. Fewer sessions appropriate to high-school technology education—the profession's longtime bread-and-butter—were being offered, it seemed, to make room for ESTE presentations.

Scholarly productivity in ESIA seems to have dropped off in the mid-1970s when it became clear that the content–method issue wouldn't be easily reconciled. A decade later, with the acceptance of technology education, scholarly focus was being placed firmly on subject matter, not children, so conditions weren't right for a resurgence in interest in ESTE. Since then, the conditions seem to have improved considerably.

One may infer from the comments overheard at the ITEA convention that ESTE may not be welcome for long if it remains solely a topic of discussion at conferences. One also may infer from historical example that as ESTE moves from theory to practice, a variation of the content-method debate will almost certainly emerge.

This would be a dangerous combination: lack of support from rank-and-file technology teachers paired with infighting among ESTE advocates, most of whom are university faculty. Perhaps this can be avoided if supporters of ESTE can reach some degree of genuine philosophical agreement. Clearly a "kitchen sink" compromise such as the aforementioned 1971 definition from the National Conference for Elementary School Industrial Arts will not suffice.

This study identified a variety of approaches to and philosophies of ESTE. Unfortunately, no debate has emerged regarding their relative merits. And until one does, a vast majority of elementary school children are unlikely to experience technology education.

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Expanding the Content Base of Technology Education: Technology Transfer as a Topic of Study

Scott D. Johnson, Elizabeth Faye Gatz and Don Hicks

The first automobile safety "air bag" was successfully demonstrated in 1955 by its inventor, who boasted in a news reel film that the next year's automobiles would have the air bag as a standard equipment feature. Looking back, one must wonder why such an important safety device took nearly 40 years to become a standard feature in the automobile industry. During the same time frame, Dr. Jonas Salk discovered a cure for the dreaded polio virus. In contrast to the air bag innovation, it was only a few months before every school child in the nation began receiving a polio shot. Why did these two life saving innovations differ so radically in their rate of transfer from the developer to the user? This question addresses two interdisciplinary fields of study; (1) *technology transfer* and (2) *diffusion of innovations* (Cottrill, Rogers, & Mills, 1989). These fields provide the link between technology development and utilization, and moves the work of technology developers into the hands of end users. Without the successful movement of technology out of a development lab and into a user's environment, the potential of new technologies cannot be fully realized.

While technology transfer typically "refers to the development of a technology in one setting which is then transferred for use in another setting" (Markert, 1993, p. 231), diffusion is used to describe the "spreading" or use of a technology within a society, organization, or group of individuals (Rogers, 1995). Technology transfer tends to focus on the producer of the technology while much of the focus of diffusion relates to the end user of the technology. Viewed from the holistic perspective of technology development and utilization, these two areas are closely interrelated and must be considered together. In this article, the term technology transfer will be defined broadly to include both the movement of technology from the site of origin to the site of use and issues concerning the ultimate acceptance and use of the technology by the end user. Adopting this broad definition of technology transfer implies that a technology has not been successfully transferred until it has been accepted and used by the end user.

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Technology transfer is not a new field of study. Although the term "technology transfer" appears to have been coined in the United States in the 1940s, examples of technology transfer can be traced back to the advent of technology itself. Formal studies of technology transfer began with the technology diffusion research conducted by European social scientists and quickly gained acceptance in a number of disciplines as an important area of inquiry (Rogers, 1995). This line of research began to grow in the United States in the 1920s and continued to expand until the late 1970s (Backer, 1991; Rogers, 1995). After a lull of nearly a decade, the study of technology transfer has once again become a focus of researchers in sociology, economics, technology, and education. It has been estimated that the technology transfer literature base now exceeds 10,000 documents (Backer, David, & Soucy, 1995).

With the recent renewed emphasis on technology transfer by business, government, and academia, educators who teach about technology should consider technology transfer as a worthy and necessary area of study. While the curriculum in technology oriented programs has traditionally emphasized technological development and the applications of technology, little attention has been given to issues of transfer and end user acceptance. In the mid 1980s, technology educators began to address the importance of technology transfer (e.g., Todd, 1985), yet little progress was made in expanding the curriculum to emphasize the links between technology development, transfer, and utilization. More recently, a cursory review of issues of *The Technology Teacher*, the *Journal of Technology Education*, the *Journal of Industrial Teacher Education*, and the *Journal of Technology Studies* for the past five years revealed only one article that addressed technology transfer directly, and the topic as covered in only one paragraph (Rogers, 1993). One would expect to find a similar void in existing curriculum documents. If it is acknowledged that technology transfer is a major factor in the field of technology, this topic should be reflected in the technology curriculum. The purpose of this article is to provide an overview of the concepts contained in relevant technology transfer literature in order to encourage future curriculum development effort.

Conceptualizing Technology Transfer

Various views of technology transfer have been developed over the years to address different aspects of the issue. Many of the early views were restricted to mean the transfer of technology between developed and developing countries. These types of studies emphasized the economic, political, and cultural differences between the developer and the receiver of the technology.

Federal agencies define technology transfer differently. When Congress passed the Stevenson-Wydler Innovation Act of 1980 followed by the Federal Technology Transfer Act of 1986, all Federal laboratories were required to develop active programs for transferring technology to State and local governments and the private sector. Through this mandate, Federal laboratories are required to develop a "process by which existing knowledge, facilities or capabilities developed under Federal R&D funding can be utilized to fulfill public and private needs" (The Federal Laboratory Consortium for Technology

Transfer, 1996). The above legislation was further amended by Public Law 104-113 that created incentives and encouraged the commercialization of technologies created in federal laboratories (National Technology Transfer and Advancement Act, 1996).

Most universities now have technology transfer centers or offices that adopt a rather narrow view of technology transfer. A recent informal survey of university World Wide Web sites revealed few educational programs in technology transfer, with most Web sites dealing with technology transfer issues related to the securing of rights to intellectual property as university-developed technologies are transferred to the commercial sector. The industry funding of university research often results in the transfer of technologies between the two entities, while at the same time provides students with experience tackling the barriers between technological development and its broader utilization. For example, some universities consider the goal of technology transfer to facilitate the efficient transfer of technology from government agencies, industries, and institutions of higher education to appropriate firms. Others tend to view technology transfer from a broader perspective, that of disseminating or diffusing technological knowledge throughout society.

In its most basic form, technology transfer includes the transfer item itself, the developer of the technology, various channels to accomplish the transfer, and the technology recipient (Markert, 1993). From a conceptual perspective, it does not matter if the developer is a private or federal R & D laboratory, a university, or a farmer in South America. Along the same line, the end user of the technology may be a commercial venture, the government of a developing country, or a neighboring farmer in South America. The important point is that a technology that exists in one setting is transferred in some way to a user in another setting who accepts and uses the technology.

Technology transfer can best be described through the use of a conceptual model (see Figure 1). The macro model in Figure 1 is based on a synthesis of published case studies of technology transfer and is intentionally very simplistic and general in nature. This model includes the (1) technological activity that leads to the development of an innovation, (2) the many barriers that may impede the transfer and diffusion process, and (3) the process through which the technology is transferred.

Technological Activity

Technology transfer begins with the development of a new technology or the modification of an existing technology. This development process occurs in reaction to a perceived want or need for a product and results in *technological activity*. This activity results in the expansion of human capabilities through the creation of technical processes, artifacts, and knowledge. All technological activity occurs within a social, economic, and psychological context (see Figure 2). The activity itself is the "result of combining ingenuity and resources to meet human needs and wants" (International Technology Education Association, 1996, p. 11). The resultant technology emerges through the combination of knowledge, thinking processes, and physical means (Johnson, Foster, & Satchwell, 1989). The outputs of technological activity are innovations or modifications of existing technologies that fall within the categories of physical, biological, informational, and organizational technologies.

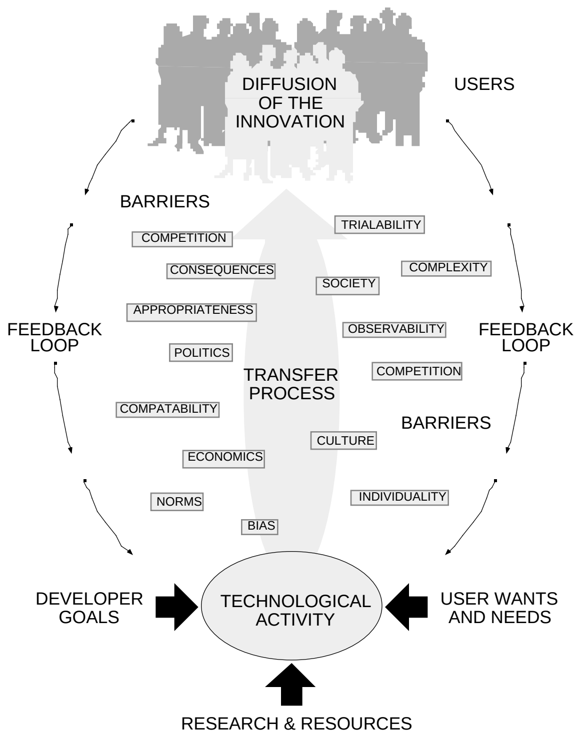

Figure1. Conceptual View of Technology Transfer

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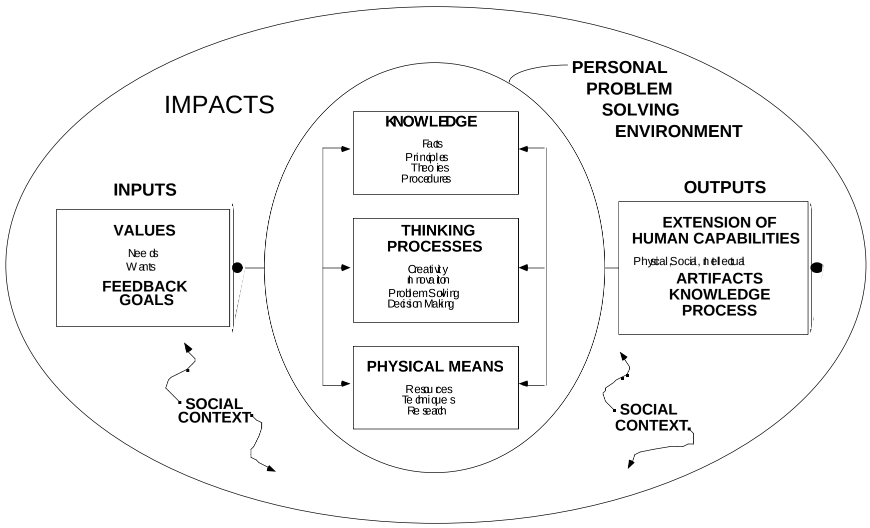

Figure 2. Model of Technology Activity

The end user should be, but is not always, the principal consideration in the design of technologies. Through early and regular contact with the end users, technologies can be developed that suit their needs. This interactive development becomes even more important when differing cultural and social values are involved. For example, in some cultures individuality and craftsmanship are valued far more than a price-break for a more efficiently produced product. Developers who realize this may ultimately be more successful in the transfer of technologies to the marketplace. Without a sensitivity for the needs of the end user and a recognition of the environment in which the technology will ultimately be used, the transfer of technology will be a difficult process. In other cases it is the technology developer's desire for prestige, money, and fame that determines the direction of technological activity. This approach to technology activity tends to ignore the end user, which may hinder the success of the transfer process.

A feedback loop is needed to complete the process. With the development of new technology comes the development of new wants and needs, leading to further technological activity. As technological developments occur, the end user becomes aware of new possibilities for using technology in their lives and may make demands, which creates a "market pull" that influences the direction of future technological activity (see Figure 1).

Barriers to the Transfer Process

Technology does not stand alone, but encompasses political, social, economic, and cultural values that can serve as barriers that impede the diffusion or transfer of technology (see Figure 1). The barriers to technology transfer exist for all innovations, but some transfers are more affected by the barriers than others.

Social barriers. It is important to recognize that transfer occurs within a social system. The social system defines the boundary or limits within which the innovation will be transferred and diffused. Most transfers assume some sort of societal judgment. An individual will not recommend a technology to neighbors if it is detrimental to them or not of substantial benefit. Similarly, news of a new technology will not be printed in a scientific journal unless its benefit has been adequately proven.

Political barriers. The influence of political barriers on transfer was evident in a problem that occurred in India, where a near-famine situation prompted the development of an agricultural research system and the reform of the bureaucracy that had driven the peasants to poverty (Parayil, 1992). Before the development of the new technology, the colonial government was interested solely in increasing the production of exportable cash crops. In this case, the political agenda largely ignored the needs of the citizens between 1947 and 1965. The political barriers to transfer were not broken until an influential change agent gained a high level position in the government. This change agent pushed the technology through the political barriers by creating partnerships between the government and research institutions that ultimately helped to avert the famine and created an infrastructure in which the technology could thrive.

Economic barriers. The role of economic barriers in technology transfer is apparent in studies of the transfer and diffusion of technology to the American cotton-textile industry (Feller, 1974). The adoption rate of a new loom was slow in the North because the industry had a heavy investment in non-automatic looms. In contrast, the new looms quickly spread throughout the South due to a relatively new textile industry that had not yet committed financial resources to a particular technology.

Personal barriers. An individual's particular concerns about a given technology seems to be an influencing factor in the degree of acceptance (Hall & Loucks, 1978). Hall and Loucks stress that individuals have different concerns about innovations and proceed through various stages before they fully accept the change. Rogers (1995) also asserts that transfer depends on certain characteristics of the end user. He contends that a very small percentage of the population, called *innovators*, constantly seek out new innovations. This group is followed by a larger group called *early adopters* who are generally eager to test new technologies. This group influences those around them and is often sought out for advice. This is a key group for change agents working to transfer a technology to identify because they can have a strong impact on their peers. Following this group is the *early majority* who tend to wait until they receive positive feedback from the early adopters about the technology before they become interested in adopting. Nearly half of the population trails behind these groups and has been classified as *late majority* and *laggards*.

Cultural barriers. Cultural barriers also play a key role in technology transfer. In many cases, the culture in which a technology is designed is different from that where it is ultimately used. Thus, it is important for designers to communicate with and understand the receiving culture (Pacey, 1986). This communication will help assure a solution that is appropriate for the culture and acceptable to social norms and values. Baranson (1963) stressed that designers should consider the characteristics of the labor force and the resources available in the receiving country. In developing countries, equipment should be small-scale, rugged, and require minimal training for successful operation. These features should not be limiting, however, as the technology should have the potential to expand as a country's needs and resources expand. He explains that "little attention has been paid to accommodating technological design to cultural traits; instead emphasis has been placed upon adjusting societies to machines" (p. 26). As systems become more automated, those in charge of technology tend to believe that more computer power will make their processes more efficient. In pulling manufacturing and design toward automation, the tendency is to give as much power as possible to the machine and leave the remaining job tasks to the worker. This automation philosophy discounts the knowledge and intuitive capabilities of workers and pushes them to resent the technology. A better approach is to design systems around the workers, which offers the workers a change from mechanistic job tasks to higher-level tasks.

The Process of Technology Transfer

Successful technology transfer is not achieved through the simple movement of technology to a new environment; it requires the development of a process and infrastructure that will help the technology "break through" the barriers described above. In some cases the technology is needed so desperately that the end user will help the technology break through the barriers. Other innovations have to be pushed through the maze of barriers to the end user by the current "owner" of the technology. The degree to which the end user wants and/or needs the new technology will determine whether the technological potential or the social constraints will prevail, and the speed with which the innovation may travel from the original source to the end user.

Communication is a key element in the transfer process. If a new product is available but the public is not made aware of it, the technology will never reach its intended market. Transfer requires human intervention for a technological innovation to become part of a larger system. The communication channels that support the transfer process include the printed word (e.g., journals, books, newspapers), personal correspondence (e.g., letters, conversations), scientific societies, formal instruction (e.g., universities, research institutions), travel and exploration, mass media (e.g., public information promotions, demonstration programs such as the model farm), bureaucratic and institutional reform, and research (e.g., adaptive research, agricultural research stations). Other, more specific, examples of transfer vehicles include personalized training (Hall, Loucks, Rutherford, & Newlove, 1975); open dialogue (Pacey, 1986); inter-industry communication (Rosenberg, 1970); education and training (Stern, 1992); management techniques and timing (Tyre & Orlikowski, 1993); student exchange programs and cooperative scientific ventures (Markert, 1993). Obviously, societies that control and limit open communication hamper the process of diffusion and ultimately the successful use of innovations.

Broad Issues that Influence the Transfer of Technology

Building on the above conceptual view of technology transfer, the remaining discussion focuses on factors that influence the transfer of technology. The ease with which an innovation is transferred from the technology development stage to the end user is contingent upon several factors. First, the process that is used to transfer a technology influences the success of the transfer. This process is described below in terms of "models of transfer." Second, the "power" or appropriateness of an innovation seems to have a significant impact on its ability to overcome the transfer barriers. Power can be defined as the strength of the human wants and/or needs related to the particular innovation that propels it through, around, under, and over the barriers; that is, if there is a strong perceived need for a technology then it will more easily overcome the barriers. This could explain why the polio vaccine got to the school children so quickly and why other innovations such as the air bag take so long or even fail to overcome the barriers. Third, the timing of the transfer is critical and fourth, characteristics of the change agent greatly influence the transfer of technology. Each of these influencing factors are described below.

Models of Technology Transfer

Many models of technology transfer exist in the literature. Tenkasi discusses four predominate models of technology transfer: the appropriability model, the dissemination model, the knowledge utilization model, and the contextual collaboration model (Tenkasi & Mohrman, 1995). The *appropriability model* follows the belief that good technologies sell themselves. Based on this model, purposive attempts to transfer technologies are believed to be unnecessary. When the developer of the technology makes it available through common communication channels (e.g., television, newspapers, technical reports, journals, conference presentations), interested potential users will adopt the technology without further effort on the part of the developer. The *dissemination model* takes the view that transfer is best accomplished when experts transfer specialized knowledge to a willing receptor (Rogers, 1995). This model suggests that the technology flows from the initial source to the end user much like water flows through a pipe as long as restrictions are kept to a minimum. The *knowledge utilization model* focuses on strategies that put knowledge to effective use in the recipient's setting. While this model has gained acceptance in recent years, it still suffers from a linear bias (as do the first two models) that the process of transfer moves in one direction from the developer to the end user (Tenkasi & Mohrman, 1995). The *contextual collaboration model* is more of a diffusion model, building on the constructivist notion that knowledge cannot be simply transmitted, but must be subjectively constructed by the receiver through contextual adaptation (Tenkasi & Mohrman, 1995). If innovations are to be transferred successfully, both the knowledge and the technology being transferred must be contextually adapted. This model goes beyond the other models that view transfer as information transmission or communication by implying that successful transfer requires learning on the part of both parties and the need to recognize the perspective of others.

Another set of technology transfer models has been proposed by Ruttan and Hayami (1973). Their model distinguishes three phases of international technology transfer: material transfer, design transfer, and capacity transfer. *Material transfer* is characterized by the simple transfer of new materials or equipment such as machinery, seeds, tools, and the techniques associated with the use of the materials. In this case, adaptation of the technology to the local conditions is not a direct concern. *Design transfer* is accomplished through the transfer of designs such as blueprints and tooling specifications so the receiver can use the new technology on site. *Capacity transfer* is the most comprehensive of the three, and involves the transfer of knowledge, which provides the end user with the capability to design and manufacture a new technology on their own. This type of transfer serves to expand and build upon a technology base while at the same time providing for learning and development of the receiver. Licensing agreements and franchises are two practical examples of this form of transfer.

A good example of these three phases of transfer is evident in Russia's attempts to develop their heavy equipment industry in the early twentieth century (Dalrymple, 1964). Russia could have decided to simply import sufficient numbers of tractors to meet their needs. However, due to the depressed economic climate, the Russians imported a small number of tractors, disassembled them to study their design, and then produced exact copies of the tractors in plants that resembled those used in the United States. This attempt at reverse engineering (Markert, 1993) proved moderately successful but the Russians' desire for capacity transfer failed because of institutional constraints (Dalrymple, 1964). Three problems hampered the Russians: (1) they were unable to copy the exact material specifications of the tractor parts, (2) they failed to educate the end users about the proper use of the tractor, and (3) their maintenance facilities proved to be inadequate. In this case, partial transfer was successful, but the creation of the capacity to design, use, and maintain the new technology was aborted because the Russians failed to recognize the entire scope of the technology transfer process. While cost constraints may require that only materials be transferred, the benefits of technology are sustainable only if the user population can adapt the technology to meet their cultural and environmental needs (Parayil, 1992).

Appropriateness of Technologies

Pursell (1993) suggests that the appropriateness of a technology influences the transfer of an innovation. Appropriate technologies are inexpensive, easily maintained, suitable for small scale application, compatible with one's need for creativity, and are relatively easy to learn to use. Appropriate technologies are those that match the needs and wants of the individual or group receiving the technology. A good example of an appropriate technology occurred during the "Green Revolution" in India in the 1960s and 1970s. The introduction of new varieties of wheat into Indian agriculture was successful partly because the wheat was *appropriate* for the setting to which it was transferred. In this case, both the agricultural production conditions and the personal taste of the consumers matched the characteristics of the wheat (Parayil, 1992). Another example of the importance of appropriate technologies for successful transfer occurred during the same time period in Mexico (DeWalt, 1978). Efforts were made by the government to provide tractors to the peasant farmers to enhance the productivity of their farms. The transfer of this technology to the peasant farmers failed because the tractors were too expensive, they were too large for planting seeds on their small plots of land, maintenance facilities were unavailable, and fuel was costly and scarce. Clearly the tractor was not an appropriate technology for these farmers. In an attempt to increase their yields by reducing the labor costs for planting and to better control the planting process by improving the consistency of the seed depth, a creative framer designed a mechanical seed drill that was pulled by animals, deposited seeds at the correct depth, and could be manufactured by a local blacksmith. Because this technology could be developed by the indigenous farmers, was simple to fabricate, and easy to use, it was appropriate for this setting, quickly gained acceptance by the farmers, and was diffused throughout the region. This is also an example of an *intermediate technology*; a technology that is at a level between the current technologies of the area and the “high tech” technologies that are available elsewhere.

Another way to consider the appropriateness of a technology is to examine its characteristics. Rogers (1995) argues that the characteristics of a technology, as perceived by individuals, influence the rate at which an innovation is transferred and diffused into the society or organization. He describes the five characteristics of relative advantage, compatibility, complexity, trialability, and observability.

- *Relative advantage*. The degree to which an innovation is perceived as better than the idea it supersedes as measured in economic terms, social prestige, convenience, and satisfaction. It does not really matter if the new technology is an advantage as long as it is perceived as one. The greater the perceived advantage, the more rapid the adoption.
- *Compatibility*. The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. An idea that is incompatible with values and norms of a social system will not be adopted as rapidly as an idea that is compatible.
- *Complexity*. The degree to which an innovation is perceived as difficult to understand and use. New ideas that are simpler to understand are adopted more rapidly than ideas that require new skills and understandings.
- *Trialability*. The degree to which an innovation may be experimented with on a limited basis. An innovation that is trialable represents less uncertainty to the individual who is considering adopting the technology and therefore is more likely to be accepted.

- *Observability*. The degree to which the results of an innovation are visible to others. The easier it is for individuals to see others using the innovation with positive results, the more likely they are to adopt it.

Timing

Timing is an important factor in the success or failure of an innovation's ability to progress from the technological activity output phase to beneficial use. There are numerous examples of technologies that appeared either ahead or behind their time, that is, they were made available either too early or too late to benefit the user. Successful transfer requires that technologies be delivered at the optimum time it is needed or wanted by the user. Timing also influences an innovation's ability to overcome the barriers. When the timing is right the barriers will be more easily overcome during technology transfer.

Change Agents

Technology transfer is accomplished by "agents, not agencies" (Burns, 1969, p. 12). Within the social environment are key players, opinion leaders, or change agents who have the influence or power to change peoples' attitudes about an innovation. For example, when Joseph Stalin of the USSR decided that a low head hydroelectric power plant would be constructed, his influence and power led to the successful transfer of new technologies from the United States (Dorn, 1979). Although Stalin was a powerful change agent, he did not have enough knowledge of the technology to lead the transfer effort. Instead, the Russian searched the world for an expert who could guide the transfer process. In this case, Hugh Lincoln Cooper was employed from the U.S. because he had both the technical expertise to guide such a project and the influence needed to see that the project succeeded. Change agents have a professional responsibility to be sensitive toward the receiving culture. They need to "consider issues and take part in decisions regarding transportation, land use, pollution control, defense, and restricting or encouraging technological activities. Sound decisions demand an understanding of the impacts, relationships, and costs of such technological activities." (International Technology Education Association, 1996, p. 8). It is important that discussions between change agents and the members of a receiving population be two-sided (Pacey, 1986). After all, the potential users of technology are experts in another sense, that of understanding their culture and society. Through this cooperation, technological solutions can be developed that adequately address social, cultural, economic, and political concerns.

Specific Technology Transfer Strategies

While the discussion of the nature of technological activity, the characteristics of technology, and the societal barriers that support or hamper transfer provides a conceptual understanding of technology transfer, concrete strategies are needed to facilitate successful technology transfers. Facilitating a smooth transition from the owners of the current technology to the end users of the new technology requires a strategic plan. It is too often assumed that innovations can be transferred simply, as if by magic, to the user. In practice the transfer process is much more difficult. When successful, the transfer process could take anywhere from a few days or weeks to several centuries. Still, some transfer efforts are never successful and languish in a sort of technology transfer purgatory.

The chances of successful transfer are enhanced by understanding the technology transfer process and by developing strategies that can enhance the prospects of successful transfer. The following lists identify many of the important strategies for successful transfer that emerge from the concepts discussed in the literature. While incomplete, these strategies highlight the complexity of issues that need to be addressed when supporting a technology transfer process. These strategies are categorized according to technological readiness questions, design considerations, and end user needs.

Technological Readiness Questions

These questions provide the basis for an initial overview or 'scan' of a user environment. Answers to these questions help assess whether a user environment is prepared to embrace and develop the knowledge needed to successfully adopt a new technology.

- Who will be using the technology?
- What is their current level of technology?
- Who are the stakeholders? the decision-makers? the influential people?
- Do the end users have the education needed to adopt the technology?
- Will training be needed?
- What are the available financial resources? Will they be sufficient to sustain the technology?
- Will the current infrastructure support the technology and its expected growth?
- What other aspects might affect by this transfer?
- Is the full benefit of the technology limited by other bottlenecks in the system?

Design Considerations

These design considerations build on the concepts of the appropriateness of technology and emphasize factors important in achieving more than a material transfer of technology.

- Design the technology and infrastructure so that it can grow with the user.
- Develop and adapt technology so that it is appropriate for the culture, and intermediate if the society's needs dictate.
- Present demonstration programs to assure small-scale success.
- Keep the end user in the loop during the design process to assure that needs are being met.
- Document technology procedures (in terms the user can understand) so that the user has as much information as needed to operate the technology independently.

- Provide research and/or training support to facilitate the transfer of knowledge.
- Maintain a systems view. Recognize that the technology is not independent, but affects other parts of the system.

End User Considerations

Central to the models of technology transfer is the role of user needs and wants in the technological development process. The issues described below build on the importance of the user in the design process and extend this consideration of users to the technology transfer process.

- Evaluate end user's needs and available resources.
- Consider how large a system the user will be able to staff and maintain.
- Identify influential people, stakeholders, and decision-makers. The power of the change agent may dictate a technology's success or failure. Facilitate communication among those involved, and foster a cooperative relationship.
- Treat the end user's values and culture with respect. Develop technology solutions that are fitting for that environment.
- Do not impose status and education on the receiving culture. Maintain two-sided innovative dialogue and establish communication channels.

Relating These Concepts to Technology Education

The concept of technology transfer has relevance for all technology education programs, including programs in elementary and secondary schools, technology teacher preparation, and industrial technology at the university level. Given the assortment of technology transfer concepts introduced in this article, that relevance may not be immediately apparent. While technology development has been a central aspect of technology education programs through the years, issues dealing with the transfer of technology and its diffusion through society have been neglected. If a goal of technology education programs is to help students understand their technological future, the curriculum must provide a comprehensive study of technology that covers the entire range from technology development to utilization. Technology transfer seems to be the missing element in a comprehensive technology education program.

What should students of technology know about technology transfer? The answer to this question certainly depends of the education level and the goals of the specific programs. As teachers of technology we need to be sure our students are aware of the issues and have the potential to facilitate successful technology transfer efforts in the future. At the very least, students should be aware that technology transfer is a much more complex concept than simply moving a technology from one environment to another. Technology itself encompasses social and cultural values and, in most cases, has a profound impact on the receiving culture. As members of a literate and knowledgeable society, students also need to know more about the technology transfer process and how it can be improved. They need to realize that there is not just one prescription for successful technology transfer. Understanding the technology transfer process and the individual, social, political, economic, and cultural influences on that process would be a likely starting place in the curriculum.

Because technology transfer, as a field of study, is relatively new and undeveloped, there are many areas in need of more investigation. Educational researchers in technology education need to identify where we fit in the process and how we can contribute to this body of knowledge. For too many years we have ignored this topic altogether.

The concepts and strategies presented in this article provide a starting point for the design of curricula that addresses the processes of technology development, transfer, and diffusion. Through a scholarly examination of this topic, we may better prepare ourselves, and ultimately our students, to recognize the importance of technology transfer.

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Critical Issues to Consider When Introducing Technology Education into the Curriculum of Young Learners

Kay Stables

As the importance of a sound technological education for learners in their teenage years of schooling becomes accepted at a global level, there is increasing interest and belief in the need to start this education at an earlier age, possibly as soon as children begin formal schooling or even nursery school or kindergarten. Some teachers have warmly welcomed the challenge of introducing technology education to children at an early age. They have found that it has allowed them to develop new dimensions to work already underway. For others the idea has been received with more caution, for a variety of reasons. Some are confused by what technology education would mean for young children. Others are concerned that limited resources would be stretched too thinly if the younger age group were included and that the primary curriculum is already overloaded. There are also those who believe that technology education is simply inappropriate with a younger age group.

Expanding the technology curriculum to primary schools raises a number of important issues. Any developments should be based on sound educational principles and thinking. This paper will explore key considerations in this area, including: 1) the value of including technology in the curriculum for young children; 2) critical dimensions to nurturing technological capability; 3) appropriate models of teaching, learning and assessing; 4) addressing the needs of the teacher; and 5) the importance of providing coherent, progressive and continuous technological experiences.

The Value of Including Technology in the Curriculum of Young Children

Human beings are born with the potential to develop as technologists. This is, in part, dependent on an amazing capacity of creating in our "mind's eye" (Archer, 1980) new ideas and new configurations in order to make our world in the way we choose it to be. This capacity is something that sets us apart from other species in much the same way that our ability to develop and utilize complex linguistic systems does. Observing babies and toddlers as they busy about their world confirms the imaginative, inventive and determined way that, right from the start of life, we begin to utilize this creative capacity and to develop technological capability.

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However, as with all aspects of development, creating the right conditions in which the potential can flourish is not necessarily straightforward. Technological capability is dependent on the ability to take action, to intervene in the made world, and to create new or improved products or systems. The children who are given more support to find out how things work, to make things work, and to create and to express themselves, the better chance there is for their technological capability to prosper. Children in the first years of life will encounter a wide variety of experiences. For some there will be an abundance of opportunities to develop confidence and skill in those aspects that support technological capability. For others the opportunities will be limited. The range of experiences will be affected by a number of economic, social, cultural and philosophical influences and these in turn will impact on the way in which capability develops. There are, for example, indications of the effect that gender based expectations have on the early technological experiences of girls and boys and the consequences this has for children's development. (Browne & Ross, 1991; 1993)

A main function of formal schooling is to take control over the experiences children have and to attempt to provide some equity in opportunities. If we accept that technology is an inherently important dimension of a child's curriculum (Kimbell, R. A., Stables, K., Green, R., 1996; Jones & Carr, 1993), there is a logic to proposing that the earlier we, as educationalists, involve ourselves in this aspect of development, the better. Leaving this to chance, or at least until children enter secondary schooling seems a little haphazardous if not dangerous.

But introducing technology into the curriculum of young children is also important because of the propensity of this age group to engage in technological activity with an enthusiasm, curiosity and lack of inhibition that creates an optimum opportunity for development. Children's sheer excitement, wonder and enthusiasm for the world around them makes for an era of rapid development. In the pre-school years, the child's lack of concern for external constraints allows for a free exploration of both their material and conceptual world. Curiosity as to how things work leads to a determination to make things work. Consequently, opportunities to develop problem solving skills are provided.

The more young children engage in technological activity, the more their confidence in their technological abilities may be established. Primary school teachers who have introduced technology into their curriculum often comment that technology activities are a valuable vehicle for all types of learning. This can include developing generic skills such as collaborative group working or problem solving, or more specific development of math or science concepts. The technology activity often promotes a rich learning environment for a whole range of learning opportunities, thus providing an added value.

Giving children a broad based experience of technology at a young age through which the foundations of technological capability can be consolidated and enhanced provides a basis from which to develop in a coherent and continuous way. But in planning technological experiences, teachers need to be aware of a range of factors that will have a bearing on development.

Critical Dimensions to Nurturing Technological Capability

Ron Ritchie (1995) highlighted three critical features of learning situations that are significant for nurturing technological capability: 1) learning through practical experience; 2) an active learning process that allows children to construct their understanding of the world, and 3) learning within a social context. A discussion of these follows.

The Importance of a Holistic View

Technology appears in several guises within curriculum documentation and taken, as a whole, three different formulations are clearly identifiable: courses that focus on developing *awareness* of technology (e.g., exploring it's impact on society), courses that focus on developing *competence* in technology (e.g., learning about electronics, learning how to shape a particular material) and courses that focus on developing *capability* in technology (Kimbell, Stables & Green, 1996). These latter courses develop a pupil's holistic capability to put ideas into action to develop the made world. Put simply, these courses develop a child's ability to design what they make and to make what they design.

There is an important place for the development of awareness and competence (and indeed the three focuses are not necessarily mutually exclusive). But, it is the inclusive, holistic approach to developing capability that is the important focus with children in primary schools. Some might find this wrong faced. It could be argued that it is better to start with developing an awareness in young children and then building from this. But this would deny the important features highlighted by Ron Ritchie (1995), and in particular the priority of learning through practical activity, so vital when considering the learning needs of young children.

Integrating Thought and Action

In the second half of the 1980's in the United Kingdom a major research project was commissioned by the Assessment of Performance Unit (APU) of the Government Department for Education and Science that aimed to assess design & technological capability. The research focused on the nation's fifteen year olds and was conducted at Goldsmiths University of London under the direction of Richard Kimbell (Kimbell et al, 1991). One of the most significant outcomes from this project was an understanding of the iterative nature of the process that people engage in when designing and making and the importance of balancing the need to think about the task that has been undertaken (both reflectively and projectively) with the need to take action to turn ideas into working realities. This work identified that both aspects are important (and their integration even more important) when considering the development of capability in fifteen year olds. Since then we have had the opportunity to consider this model of activity in relation to younger children (Stables, 1992a; Kimbell, Stables & Green, 1996) and have found that it is equally applicable. This model has received corroboration from elsewhere (Anning, 1993) and the importance of developing 'thought' skills and 'action' skills in primary age children is increasingly recognized as critical in technology (Benson & Raat, 1995).

The Importance of Play

Play has been seen by many educationalists as a critical factor in a child's development and this is particularly so of the development of technological capability. In particular "making and playing" (Coghill, 1989) can be seen as the early manifestation of capability, and the very act of being involved in play is crucial to the nurturing of this capability. This is largely due to the fact that play allows a child to enter into an imaginary world, through which they can gain firsthand experience in an unconstrained way. While not dealing directly with technological capability, Bruce (1991) sums up neatly the dimensions of play that provide the conditions through which technological capability can flourish, starting with the importance of firsthand experience.

> ...as we experience, so we struggle, manipulate, explore, discover and practice in order to wallow fully and become proficient....If we can use first hand experience as a means towards wallowing in experiences, and being proficient we have a sense of control over our lives....This sense of control impinges on self-esteem, self confidence, autonomy, intrinsic motivation, the desire to have a go, to take risks and to solve problems, and the ability to make decisions and to choose. (pp 82-83)

Through play children develop mastery, confidence and control. Encouraging them to utilize such skills within technological activity allows for further consolidation.

Building Positive Attitudes

Developing children's skills assists in the creation of positive attitudes such as self esteem and motivation and these attitudes in their turn help establish the conditions in which technological capability can thrive. However, such attitudes can be both built and destroyed through engagement in technological tasks and so it is important that children work in an environment that is at the same time supportive and challenging. They need opportunities to work on tasks that are within their capability, but that still have the potential to stretch them, where risk taking and failure are not seen as negative or handled destructively. The need to develop just such a learning environment has been highlighted by teachers working on a primary technology initiative in the United States—"Project Update" (TIES, 1994). The teachers, who have by and large come afresh to technology activities have developed insights both by working through challenging tasks for themselves and by involving pupils in such activities. The resulting view is that the children should be involved in risk taking situations, where failure is seen as a positive learning experience and that this approach can prevent the children from placing "false ceilings on what they can learn and accomplish" ("Project UPDATE," 1994, pp. 21-24).

Being Aware of Value Positions

Technology is intrinsically a value laden phenomenon as developments are always driven by the needs, wants and aspirations of individuals or groups of people. Diverse needs mean that individuals will often perceive the impact of any technological solution differently - some may see a solution as good, while for others it is an unmitigating disaster (for example, automobiles are good for getting places, but bad for the environment). Because this value laden position is a reality, it is important that children are encouraged to see the issues surrounding any technological decision, and to be involved in the decision making in a meaningful way. For this reason, primary teachers are increasingly involving children in technological tasks where the value positions are clear to the children and are presented in a way to which they can relate, such as the ways in which choice and use of materials impacts the environment.

Access for All

Developing positive attitudes towards their peers and understanding the value of working with others is an important aim of technology education. Within this, the importance of children developing respect for each other, and in particular accepting the rights of all to engage in technological activities is vital in creating a nurturing learning environment. This means that it is critical that technological activities take place in an atmosphere where stereotypes are countered and differentiation strategies are utilized to allow all children to realize their potential. This is particularly so in primary schools as value positions can be adopted at a very young age, and if not challenged by real and positive examples can become intransigent. Technology activities are particularly rich in potential for allowing all children to succeed, thus providing living proof to challenge negative assumptions. However, in order to support the development of all children, particular consideration needs to be given to the ways in which young children learn and consequently the range of experiences that teachers need to structure for them.

Appropriate Models of Teaching, Learning and Assessing

In order to operate effectively, children must develop a range of contributory skills - procedural, manipulative and communicative. This must occur alongside conceptual understandings, both of how to make things work and how to meet people’s needs and wants. Few people would disagree with this standpoint, but the way in which such contributory skills are best developed often is the cause for disagreement. This section raises some of the issues surrounding this debate and also offers some examples to illustrate approaches drawn directly from the classroom.

Children as as Active Learners

The ways in which primary education has developed in different parts of the globe will relate very much to the traditions and ethos of the culture in which it has developed. In the United Kingdom, while there are differences between one school and the next, the overarching model of learning in primary schools is one which is seen as “child centered” and in which children are viewed as active learners. This means that, for many young children in the UK, their school (and hence their technology) experience will be managed in a classroom environment which lacks the formality of the secondary school, where much work will be handled in an integrated way, initiated by topics or themes. Moreover, children will be familiar with working both collaboratively and individually. Similar models will be found elsewhere in the world, but some cultures will have a different tradition. It is important to identify these differences here, in order to put what follows in context, as many of the examples used are drawn either from the UK or from school systems that have elements in common with this approach. It will therefore be important that readers evaluate each model, strategy and example that is given in terms of the value it holds for developments within their own school setting.

Educational or Vocational/Instrumental Needs

Any debate about approaches to teaching and learning technology in education must consider the often conflicting claims for priority in addressing educational or vocational needs. For very young children, the focus and priority must be on their educational development. Indeed it's important that educators protect their rights to remain children. The issues of the development of their technological capability should not be clouded by introducing such issues as the economic well being of a nation or how a work force is going to be trained for the next generation. This is not to say that we shouldn't be concerned for the future of the children and do our best to ensure that they develop their potential to lead happy and satisfying lives as adults. It is more to suggest that the specifics of the technological experience of six year olds should not be planned by looking at the skills required for them to pass examinations at the end of compulsory schooling, or those that will allow them to become the mechanical engineers, architects or food technologists of the future.

However it's important to consider two further dimensions within this. First there is increasing acceptance that general technological competencies are more appropriate for young children in a rapidly changing technological society than are specific skills (Jessop, 1991; SCANS report, 1991). By developing a more generic potential from a young age, this next generation may be more comfortable, confident, and secure in their own capability. As a result, they may be in a better position to utilize it flexibly across a wide range of settings. Where these skills are developed through an integrative, holistic approach, there may be greater propensity for them to be utilized in a broad range of settings, hence furthering the potential of technology education.

Activity Driven by a Need to Know

It is also important that knowledge and skill are not seen only in terms of vocational development. The introduction and development of knowledge and skill on “need-to-know” basis can serve to enhance the developing capability as young children resolve tasks in a satisfying rather than frustrating way. Readiness for learning is an important concept - trying to introduce a new skill or concept to a learner too early can at best be wasteful of time and at worst damaging to their confidence if they perceive themselves as a failure. The concept of teaching knowledge and skills in technology on a need-to-know basis, introducing new material to children at the point they need it to further pursue their designing and making, (Kelly et al, 1987) pays attention to the notion of readiness, but goes further to highlight the importance of teaching something new in context.

In recent classroom research conducted at Goldsmiths (the UTA Project[1]) this approach was very effective. In one instance, a 5 year old was designing and making a house for a toy spider. He had made a slide for the spider to play on, but was concerned that the spider couldn't get to the top of the slide. He thought a ladder would be the answer, but needed to know how to make one. The teacher intervened at this point, first to support him to visualize and then draw a ladder, and then to introduce new skills of measuring, marking and cutting wooden dowel and using a low melt glue gun to join the ladder together. The timing was just right, and having developed and consolidated his new skills, the child went on to use them in further work. An older child, age 10, was making a model fairground carousel. She had an idea that it was possible to power the carousel using weights and pulleys, but had no understanding of how this could be done. The teacher stepped in and worked with the child to introduce new understandings about pulleys and then supported the child to utilize this new knowledge to make her roundabout work. In a third incident a whole group was working on making model houses and supermarkets for an exhibition. At the point at which they needed to make stable models of their structures, the teacher demonstrated a range of ways of doing this. Introducing new knowledge when the need is triggered by the project allows a teacher to identify opportunities for progression and critical windows for supporting this. We concluded that it is vital that pupils are engaged in designing and making that is just within or just beyond their reach. This challenges them constantly to extend into new understandings in order to achieve success (Kimbell et al., 1996, p 76)**.**

Problem Solving

A complementary approach, particularly in relation to developing new conceptual understandings, is the use of problem solving. As mentioned earlier, finding out by solving problems is a strategy used by very young children long before they engage in formal schooling. The UTA Project (Kimbell et al., 1996) was particularly conscious of the effective use of this approach with older primary children (8-11 year olds). We the researchers witnessed a range of new understandings being developed in this way: a child working out how to make a slipper that would fit his foot by experimenting with scissors, paper and pins to make a working model; a pair of children working out how to make a tiller for a galleon that could genuinely be used to steer it; a child working out how to make a Venetian blind for a model house she was making; and so forth. In all cases, the solving of the problem became a motivational hook and the sense of

[1] The UTA (Understanding Technological Approaches) Project, sponsored by the Economic and Social Research Council (Research Award R-000-23-3643) was conducted at Goldsmiths University of London between 1992 and 1994. It used close observation techniques to build case studies of technological project work from children from age 5 to age 16. For a full description of the project see Kimbell et al 1996.

challenge and achievement was tangible. Problem solving inevitably involves children in risk taking situations and it is important that it is conducted in a supportive atmosphere. It is equally important that the teacher is on hand to either provide prompts if a child meets a challenge that is too demanding to be achieved independently, or to provide answers that counter any misconceptions a child might develop.

Hands on Exploration

Again linked closely to the previous approach is a belief in learning through hands on exploration in the context of problem solving research. In their collection of activities from across Europe, Benson & Raat (1995) include a valuable example of young children researching material properties through hands on exploration. Six and seven year old children were provided with a collection of different types of wire and gauze and simple tools that could be used to cut and bend them. They were introduced to an activity aimed at finding out as much as possible. They did this first by observing and then by manipulating about the way the wires could be bent, cut and twisted. Initially they explored possibilities in a free way and then explored ways of using their experience to identify technical and decorative uses. This kind of activity builds on the approach very young children adopt to find out about their world. While it is in many ways quite structured, its antecedents can be seen in the free flow play (Bruce, 1991) of the toddler, as can it's value in developing both understanding and mastery.

The UTA Project (Kimbell et al, 1996), found that hands on exploration was a useful way for children to model design ideas. Working directly with materials appeared to free children to think in 3 dimensions, to work kinesthetically with materials and create their designs by trial and error. But, they did this with a growing understanding of the working properties of the material. This was particularly evident with one ten year old child who used this approach to build a complete model staircase, including a landing that turned the staircase through 90 degrees.

Modeling Ideas

The above examples illustrate appropriate ways of encouraging children to develop understanding and also to model their design ideas. They demonstrate how children's ideas move from hazy ideas in their heads towards working, tangible realities. The approaches all have a firm foundation in models of learning utilized in many primary schools. However, a great deal of concern has been expressed in the UK that the development of technology in the curriculum of young children should not be dominated by paradigms developed in secondary schools, or seen as a mere watering down of work done with older pupils. These concerns have related as much to the approach to work as to the content of lessons. Some of these concerns have been confirmed by situations where a primary teacher has, for want of any other example, employed secondary school approaches, only to find them ill suited to supporting the needs of the children. An illustration of this has been seen in approaches to getting children to generate ideas where the perceived approach has been to ask the children to design what they want to make, in advance, by drawing on paper. This has led to frustration for teachers because they have been uneasy with the relationship between what the children drew, what they eventually went on to make (often bearing little resemblance to the initial drawing) and a growing sense that the act of making the drawing was not supporting the child's process or development. It has also led at times to frustration on the part of the children. The act of trying to express a 3D artifact through 2D on paper (an act that Angela Anning (1993) so aptly points out "would tax many adults") provides confusion and complexity rather than clarity - a clarity that perhaps would have been more attainable by modeling the idea directly in 3 dimensions using construction kits, modeling clay, paper or cardboard.[1]

This concern, particularly in relation to the procedures children use in technology tasks has prompted recent research in the UK focusing specifically on the early years (Johnsey, 1995; Roden, 1995). Cy Roden's work with 5 year olds has raised issues about whether the strategies commonly used by young children are replaced by others as they get older, and suggests that there may be an optimal time for the development of any strategy. This raises the need for further consideration being given to indiscriminately introducing a strategy to one age group that is utilized with older learners. Findings of the UTA Project clearly indicate that children of the same age utilize different working styles, and given the freedom to do so, adopt procedures that best suit their own style. Perhaps the key message here is that, whatever their age, a range of different and appropriate strategies should be accepted and encouraged. What is most important is that children express and develop ideas. The ways in which they do this should be seen as a means to an end and not an end in themselves.

The Importance of Context and the Use of Fantasy

Teaching within meaningful contexts is important in bringing relevance to an activity and to help children take ownership of tasks they undertake. Within technology education the context serves a further purpose. The context becomes a vehicle to bring the design issues into the open. Children designing homes for toy spiders have to think about a range of criteria that relate to creating successful homes—keeping dry and warm, creating a stimulating environment and so on. By addressing such considerations, the task the children are engaged in becomes richer and the children's decision making more thoughtful. One very important strategy that helps a child engage with a context is to use fantasy or role play (Stables, 1992b). This was the case with a group of six year old children whose teacher had taken the topic of explorers for the focus of their work. Through role play and imagination, the class had gone on a sea voyage, been chased by pirates, shipwrecked and subsequently washed up on a deserted island. The children enacted the experience of spending their first night on the island - with nowhere to sleep, nothing to keep them warm and dry, and nothing to protect themselves from wild animals and the pirates. As a result, the children

[1] For a more detailed debate on the use of drawing as a designing tool with young children see, for example, Samuel 1991, Anning 1993, Constable 1994, Egan 1995.

identified the need to build shelters and set about designing and making model shelters that would provide warmth and protection, that would allow rain to run off, that were camouflaged from the pirates, and that had secure entrances, some protected by booby traps, should the pirates track them down. Each decision that was made was governed by the fantasy situation but was made in a critical and thoughtful way. In order to realize their designs, children needed to develop new skills and understandings such as how to make a pointed roof, how to make a house on stilts that didn't wobble, and how to make a fence that contained a hinged gate. The level of learning was made possible by the willingness of the children to engage in the fantasy world.

The Importance of Reflection

The model of technology being promoted here is one in which children are thinkers as well as doers. Consequently the teaching and learning approach needs to be structured to develop children's ability to reflect on their work. Young children develop many skills initially at a tacit level. They may, for example, have developed skills in cutting cardboard shapes accurately without being conscious of how they do it. As educationalists, it is important that we help children turn their tacit understandings into explicit ones - to be 'metacognitive' about their experience. Providing opportunities for reflection and resourcing these with appropriate prompts is critical in achieving this. There are good examples of teachers facilitating this by encouraging children to use devices such as logs and process diaries (Rogers & Clare, 1994). Putting children in a position where they take responsibility for their actions was seen as one way of achieving this in Project Update (TIES, 1994). The author gives the example of children asking the teacher when their project would be finished. The question was turned back on the children - when did they think it would be over? The children discussed this and then replied, "It will be over when it does what we said it would do." The Project reporters point out that this statement showed that the children "had to re-examine their thinking to determine what constituted an adequate purpose," a process which required them to bring their thinking out into the open, thus making it explicit and available for reflecting upon.

Models for Monitoring and Assessing Work

Supporting the children to develop reflective skills will also facilitate the way in which they can evaluate both the outcomes of their task and the progress they have made. This self assessment has often been a feature of the logs and process diary approach and can contribute to the overall assessment by the teacher. By involving the child in the process, they are empowered to take control over their own learning. This approach has been piloted across the primary age range, starting with 5 year olds (Rogers & Clare, 1994).

If such assessment relates directly to project work, then the assessment process can be integrated into the learning process. Children can assess themselves and be assessed by their teacher while working on task thereby allowing for "authentic assessment." However, it is important to distinguish between monitoring a child's experience (in order that the teacher can keep track of the experience and use this to help plan a broad and balanced curriculum) and assessing the capability they display (in order to keep track of the child's progress and, within this, strengths to be built on and weaknesses to be addressed).

It is also important to consider what is the most appropriate model of assessment to be utilized. As has been discussed earlier, technological capability is an integrative capability that draws on and draws together a person's knowledge, skill and understandings. Because of it's integrative nature, the capability is best developed in an holistic way, and hence assessed in a holistic way (Kimbell et al, 1991). This approach allows teachers to build an overall picture of a child's capability, within which they can look to diagnose specific strengths and weaknesses. Once identified, action for development can be taken within the context of the child's overall capability, identifying strategies (that can perhaps be shared with the child) to develop specific areas, such as a child's ability to plan, to reflect, to make and so on.

"Taught not Caught"

Developing technological capability requires teachers to structure activities and inputs in such a way that what children learn, in terms of procedures, concepts and skills, is "taught not caught" (Anning, 1993). Moreover, the children should be active participants in this process. This is not to marginalize experiential learning or to discount the potential of serendipity, but rather to identify the importance of teachers taking an active role in determining both the what and the how of the learning. This means that teachers need to have the personal knowledge, skill and confidence to resource this, which, because of a lack of training provision, is not often possible. It is therefore important to now turn to those issues that relate to meeting the needs of the teachers involved in the enterprise.

Addressing the Needs of the Teacher

Earlier the importance of the'readiness' of children to learn was emphasized. This concept is equally important when considering how teachers can be supported to engage successfully in technology education.

Very few primary teachers have received formal training in the teaching of technology education. Even those countries that have decided to introduce compulsory technology education into their primary curriculum, and who have set up training programs to facilitate this, have a back log of unprepared technology educators teaching in primary schools. The task of providing professional development for them all is massive. Our experience in the UK (where by some standards there has been a considerable input of resources, although nowhere near enough to meet teachers' needs), suggests key areas to be addressed in helping teachers move forward include:

- developing teacher's understanding of what technology education is;
- helping them see how the work they currently do, and the experience they already have, can be adapted to allow technology activities to grow from the work already undertaken with the children;
- developing their confidence in their ability to build on and utilize their previous experience;
- identifying a broad but manageable range of activities for teachers to start from, and providing them with personal, hands on experience with the activities before they embark on them with children;
- providing opportunities (through dialogue and printed materials) for teachers to share good ideas and good practice and build a repertoire of successful activities.

Pilot projects that have been structured to address the above areas have provided good models to build on and have illustrated both issues to be dealt with and strategies that contribute to success. Taking each of the key areas above and illustrating them from some of the work that has taken place in recent years will perhaps help clarify some ways forward.

Developing Teachers' Understanding of Technology Education

From 1990-1992, we at Goldsmiths developed a set of National optional assessment tasks to help primary teachers assess technology capability. This project was linked to the introduction of the National Curriculum in Technology and the tasks were designed not only to help teachers make assessments, but also to help them structure and manage technology activities (sometimes for the first time). Teachers were very confused about technology - was it computers, applied science, or craftwork? We wanted them to understand the simple message that technology was about designing and making products that would meet peoples needs and desires and that the children needed to 'design what they made and make what they designed'. We started by providing activity guidelines and involving teachers in group discussions and 'hands on' activity to see how the guidelines could be used. They then worked through the activities with the children, providing concrete examples to evaluate. For many teachers this was a daunting and sometimes painful task, but, in terms of developing their understanding, the comments made on evaluation questionnaires speak for themselves:

> "Excellent illustration of the D&T[1] process - particularly useful for INSET" (In-service training, (Year 2 teacher)

> "This was a really worthwhile project to be involved in, for the class and myself. I feel the next D&T work we tackle will see a marked improvement ... because of the learning done during this task." (Year 5 teacher)

[1]D&T - Design and Technology, is the National Curriculum title for this activity in the UK.

> "I've learnt a great deal about D&T and what the children are capable of"
> (Year 6 teacher) (Stables, 1992c)

The Learning in Technology Education project, carried out in New Zealand from 1992-1994, involved both primary and secondary teachers for this same purpose. Introducing technology education to the primary teachers illustrated several parallels with the researchers' experience in the UK. At the start of the venture the primary teachers expressed similar confusions about the nature of technology education. But again, following a process of discussing technology education, exploring exemplar activities and then planning, implementing and evaluating their own activities, it became evident that the teachers' understanding (and with it their confidence) had grown (Jones, Mather & Carr, 1994).

In both of these examples, certain aspects are worth highlighting: the teachers were involved in first hand activity; they had opportunities to discuss what they were doing with others going through the same experience; and they were actively encouraged to evaluate their experience. Just as is so valuable with children, the teachers were provided with the opportunity for action and reflection—to be both 'thinkers' and 'doers'.

Building on and Adapting Previous Experience

Once primary teachers become involved in a technology activity, they realize how much they can draw both on their general teaching skills and also on work from other areas such as science, mathematics, and art. Working from strengths is important, but within this it is necessary to help teachers see how previous work might need a shift in emphasis to develop as a technology project. This was the case with a teacher who had taken a topic of "Down our street" with a Year 2 class. This topic initiated science work as children explored the materials the street and the buildings were made from, history work as they investigated the history of street lighting, and art work as they drew the local buildings and made a street scene frieze. However, the teacher was having trouble locating a starting point for the technology work. Following discussions during which we explored the importance of the concept of need and purpose in technology, she introduced to the class an idea that they should think of ways of "improving our street." The addition of this one word, and the shift in emphasis it indicated had an amazing effect on the children's imaginations and within no time they had changed their classroom into a planning office, re-designed the signs and blinds over local shops, explored ways of designing pavements by laying paving slabs in interesting patterns, and building a model to show how the street could be turned into a pedestrian precinct.

Working from teachers' strengths allows them to make a start on a technology project (not necessarily as large as the "Down our street" project became), and from this to build their confidence to embark on activities without feeling they have to know all the answers. As one primary teacher from the Learning in Technology Education project (Jones, Mather & Carr, 1994) said, "It's taking risks, not only asking the children to take risks, but the teacher too…. I think that learning, as far as I'm concerned, is being a co-learner with my children. Not assuming that I know everything." (p. 27)

In the Goldsmiths project, in a questionnaire aimed at identifying the primary teachers' state of readiness to teach technology, there was a common pattern to the teachers' feelings about their own strengths and weaknesses. Often seen as an area promoting confidence was the teacher's ability to introduce and discuss work with children, whereas a common lack of confidence related to lack of skills to support children's making (Stables, 1992c). This latter concern is a very real one and is the reason behind much primary technology in-service work being focused in this area.

Providing Teachers with 'Hands-on' Experience

An approach that breeds both confidence and skill in supporting children's making, is one which provides teachers with opportunities for hands-on practical work themselves. This is common in in-service courses in England and was a feature of the early work done with teachers involved in Project Update in the USA. The value of such activity is that the teachers not only develop the specific skills required, but the activity also provides a reference point for planning classroom activities—how long will the activity take, what resources are needed, what will the children need to be taught, will it be best for them to work as individuals or in groups? Teachers are able to see how best to manage the activity.

Building a Repertoire of Good Practice

An outcome of each of the three projects mentioned here was a collection of classroom activities to be shared. The optional assessment tasks were trialed and evaluated (though not initiated) by the teachers, and modified accordingly before being made available to all teachers in England and Wales. The Learning in Technology Education project produced examples initially of activities drawn up by the research team, but once the teachers had planned and trialed their own, these were added into the bank. Project Update has been set up with a clear aim of supporting the teachers involved to become curriculum writers, as their planned, trialed and evaluated activities are edited into a collection of classroom materials supporting not just technology, but also science and mathematics.

In any area that is as new to the primary curriculum as technology is, sharing good ideas and good practice is imperative. Developing a repertoire of good practice not only enables new teachers to be "fast forwarded" into the venture, it also builds a solid foundation that gives confidence within the profession.

Providing Coherent, Progressive and Continuous Technological Experiences

This repertoire should not only provide good activities and support effective learning in an isolated way, but also should provide a model for progression in order that children have a coherent experience. However, recent research on the UTA project (Kimbell et al, 1996) has shown that England has been very concerned to develop both primary and secondary technology education yet less concerned to ensure that there is clear and smooth progression between the two phases. In particular, very different teaching (and hence learning) styles have developed, creating a discontinuity in the children's experience. As noted earlier, it is very important to consider the developmental needs of the young child, rather than the vocational needs of the country. It is important, however, to take account of the shift in preoccupation that will inevitably be present in the final years of schooling. In England we still have much to learn about how we can manage the shift in emphasis in a way that optimizes the development of the child's capability. There are however promising signs of dialogues developing between primary and secondary teachers as they become aware of the need to address this issue in a positive way. With hindsight it may have been more

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Editorials

Going, Going, Gone? Recent Trends in Technology Teacher Education Programs

Kenneth S. Volk

Several years ago, I examined the enrollment trends in industrial arts/technology teacher education programs from 1970 to 1990 (Volk, 1993). The analysis indicated university programs and student enrollment numbers suffered a precipitous decline from the 1970 levels. For instance, by 1990 the number of students graduating with industrial arts/technology education teaching degrees were less than one-third the number graduating twenty years earlier. An examination was also made as to the detrimental effects non-teaching options such as industrial technology had on teacher preparation program numbers.

As a result of this analysis, it was estimated that if the downward trend continued, the demise of the technology teacher preparation profession would occur near the year 2005. This doomsday scenario for technology education programs was not meant to be fatalistic. Rather, it was hoped this bold prediction would challenge the profession and serve as a catalyst for more discussion on the health and direction of the programs.

To re-examine this original prediction of the profession's demise, more recent data were collected using a similar methodological approach. The *Industrial Teacher Education Directory* (Dennis, 1995) was again used to compile the number of graduates from US technology teacher preparation programs. This next five-year interval was combined with the original data showing the graduation rates and projected trend (see Figure 1). The data for 1995 indicated less than 1300 graduates received technology education-related degrees, adding support to the original projection.

Influences

There are several factors which may be influencing the future trends in technology teacher programs. The shift in teacher recruitment emphasis, the

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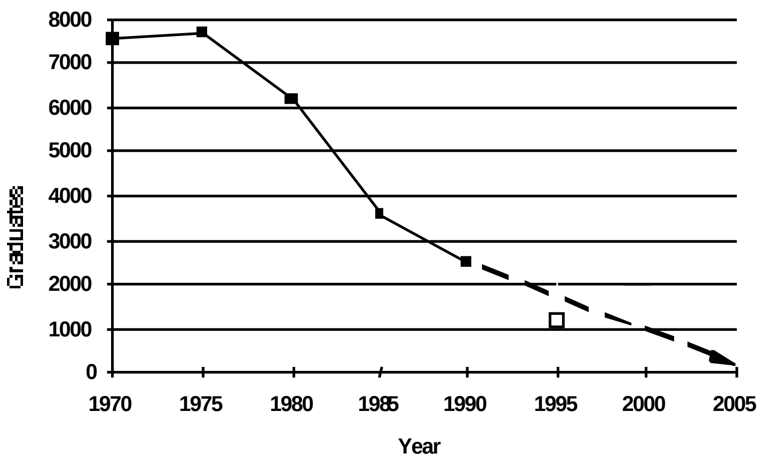

Figure 1. Original and projected industrial arts/technology teacher graduation rates

decreasing pool of professionals actively debating issues, and the potential for a diminished role for technology education as a stand-alone subject each have the capacity to influence the character and survival of the programs.

Although the data indicated the total number of students receiving bachelor's degrees has been falling significantly, those actually obtaining teacher certification through alternative routes has not been ascertained. For instance, with alternative certification programs such as the Military Career Transition Project offered at Old Dominion University, a number of new teachers entering the profession would naturally be greater than reported in the *Directory*. But, to what degree these options are meeting the actual needs of schools to have qualified technology teachers remains of question (Young-Hawkins, 1996).

Besides the potential that recruiting a cohort of technology teachers through non-degree options may perpetuate still-more skewed demographics in technology education (i.e.; male, ex-military, technically oriented as opposed to arts and humanities), a program survival issue concerns the role and mission these options have within degree-granting institutions. Given the reliance on determining faculty and program continuation based on Full Time Equivalency calculations and numbers actually graduating, can technology teacher preparation programs viably exist, relying on such non-degree granting initiatives?

The pool of professionals actively debating technology education issues may also be decreasing. Program closures and the small number of students graduating from existing programs have reduced the university professionals actively concentrating their efforts on technology teaching matters (Evans, 1992). Wenig commented on this reduced professional role by lamenting the Council on Technology Teacher Education's gradual loss of "membership, power, and influence" in the last 10 to 20 years (1995, p. 529). Similar reductions in professional discourse is further illustrated by the recent collapse of the annual Technology Education Symposium series, decreased attendance at regional meetings such as the Southeast Technology Education Conference, and the minimal participation in committees at ITEA conferences, resulting in the abandonment of long-standing committee structures in favor of more-targeted task groups.

University faculty housed in many programs will more likely shift their research and publication focus to non-teaching industrial technology areas; a reflection of their increased interests and responsibilities (Volk, 1993). Sanders (1995) discussed one aspect of this change in professional dialog. He noted how *The Journal of Epsilon Pi Tau*, originally created for teachers and teacher educators, increased the number of technical articles and eventually changed their name, in response to more-technical and less education-centered readership.

Given the lack of opportunities in recent years for young professionals to enter university positions (McAlister, 1993; Scott & Buffer, 1995), ample discourse which compliments or challenges the existing (and more-mature) status quo may be waning. The corresponding decrease in doctoral degrees granted and diminished new professional opportunities in technology education teacher preparation programs does not afford the incentive or opportunity for new ideas to be promoted. Compounding this lack of available "fresh" dialog, the age of technology teachers has been increasing. Through data supplied by International Technology Education Association (personal communication, August 14, 1996), 14 percent of ITEA's members in 1981 were in the 18-25 year old age group, while in 1995 only 8 percent were in this category. What this suggests is that the future source for new higher education professionals experienced in teaching technology education may be seriously jeopardized.

Finally, as a stand-alone subject, trends have not been encouraging. With programs closing in public secondary schools (Scott & Buffer, 1995) and subjects such as science using much of the equipment, activities and concepts "unique" to technology education, the need for a separate discrete subject has been reduced. Granted, initiatives encouraging technology education in elementary schools and the *Technology for All Americans* project may increase public awareness of the subject, but the need for producing teachers specialized in the discipline may not be forthcoming or necessarily required.

It is quite possible that the subject of technology will be introduced as a one-time experience for those preparing to be elementary teachers, hardly requiring a full technology department to support the effort. Also, should the concepts outlined in the *Technology for All Americans Standards* be incorporated into existing science, mathematics and history curriculum, any justification for a unique facility, curriculum and teacher dedicated to technology is moot.

Is This The End?

The likelihood that the demise of the technology teacher preparation programs will occur around the year 2005 is not without potential revision. First, economic incentives might encourage more young people to enter the technology education teaching profession, as public awareness responds to teacher shortages. Second, through political action via education departments, the importance of technology education being a required subject for all secondary students may develop. Already this has happened, with the state of Maryland leading the way. Finally, from students' experience derived through innovative technology education programs, a true desire to teach the subject for personal satisfaction, interest and motivation may develop.

In some programs, the declining numbers have started to level off or even turn around. However, this trend is few and far between. More questions must be posed in order to find possible solutions to the declining numbers. What was so unique about the students and programs of the 1960s and 1970s that the attractiveness, energy, enthusiasm and numbers were at its zenith? Why are students not considering a career as a technology teacher now? Why does the public, including other educators, not fully appreciate or understand the need to learn about technology? Is the leadership of the profession not tolerant enough or accepting of more-traditional programs that still attract student interest? What is being done right in those few technology teacher preparation programs that are succeeding?

It is very doubtful technology teacher preparation programs lost will ever return, and that very few new programs will have the opportunity to start, given the retrenchment efforts and budget cuts in higher education. We must therefore give serious attention to the issues influencing the downward trend, for the survival of the technology teacher profession is at stake. For as the numbers indicate, if we do not address the issues, soon we will be going... going... gone.

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Curriculum Focus for Technology Education

Robert C. Wicklein

Determination of a curriculum development paradigm for technology education was identified as a primary concern for the profession (Wicklein, 1993). The lack of focus for curriculum content has created a somewhat disjointed approach to the study of technology. It has also diminished the impact that technology education could have on education and society. Satchwell & Dugger (1996) described the diversity within technology education to be "ranging from basic programs reflective of early manual arts to state-of-the-art technology education programs" (p. 11). Zuga's (1989) seminal research on relating the goals of technology education with curriculum planning identified major curriculum design categories. Curriculum design and development in technology education has centered around these five categories: *(a) technical performance or processes; (b) academic focus on the specific body of knowledge relating to industry and technology; (c) intellectual processes that concentrate on critical thinking and problem solving; (d) social reconstruction through realistic or real world situations; and (e) personal, learner-centered focus on individual needs and interests* (Zuga, 1989). The strengths and weaknesses of each of these design approaches must be evaluated, possibly coordinated, and eventually implemented into technology education curriculum planning if the field is to ever have a central theme or focus.

First Things First

Before technology education, as a profession, can determine the focus of the curriculum we must understand what technology education is supposed to achieve. Significant debate over the past decade has established a fairly consistent rationale for the study of technology and the need for technology education. A reasonable explanation of technology was postulated by Wright, Israel, & Lauda (1993), when they said: "Technology is the practice used to develop, produce, and use artifacts and the impacts these practices have on humans and the natural world." Therefore, technology education should encourage students to study the (a) processes used by practitioners (technologists) to develop new technology (this may include critical thinking and problem solving), (b) areas of technology which represent the accumulated

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knowledge of practice (specific technological applications), and (c) impacts of technology on society and the environment (Wright, 1992). With this as a basis for the field, curriculum development can begin.

As development of curriculum is considered, disagreement arises. Here is where the curricular friction begins to take place and be noticed. For much of the profession the current curriculum framework is little different from the old vocational models used in years past that concentrate on the technical aspects of selected tools and materials. It is packaged differently, modules are used instead of unit shops, computers and robots are used instead of jack planes and handsaws, but the philosophical basis remains the same. Educators concentrate the majority of their efforts on the technical procedures used to create artifacts and give the processes used by technologists and the impacts of technology on society only cursory attention. Students sometimes gain knowledge about the technological processes and the impacts of technology as a by-product of the curriculum. These outcomes occur in a haphazard way, however, rather than through a coordinated curriculum that shares the stage with the major elements of the technology education curriculum.

The Curriculum vs. Application Gap

There is a schizophrenic approach to curriculum design and student learning. There is a serious duality between what professional educators *say* about curriculum in technology education and what is *done* in the classroom. We say technology education should encourage students to study the processes used by technologists to think critically and solve problems. However, at best we present rigid linear models that relegate students to prescriptive solutions as if there was only one approach to the problem. We say technology education should encourage students to study the impacts of technology on society and the environment, yet we devote the vast majority of classroom time to specific and sometimes obscure technical skill development. The gap between what we say in curriculum designs and what we do in the classroom continues and may even be widening. The content of technology education curricula today is more geared toward learning cognitive processes than what has existed in years past with industrial arts. However, the approach that many teachers take to address this curriculum tends to concentrate on technical skill development which differs little with the industrial arts programs of yesteryear. An analysis of the psychological preferences of teachers within the profession has yielded some light on this issue. Wicklein and Rojewski (1995) compared the psychological type profiles of technology and industrial arts educators. Their analysis found a relationship between professional orientation (technology education vs. industrial arts) and psychological type preference. While the industrial arts teachers preferred an introverted, step-by-step approach to learning and teaching, the technology educators preferences leaned to a more extroverted, intuitive approach. Keeping in mind that a large percentage of current technology teachers are *"retooled"* industrial arts teachers, these differences in psychological types start to explain the reason for the gap in curriculum design and classroom application.

Learning About Learning

Curriculum developers within the field of technology education can learn a lot from an analysis of current learning theory. The building block model for education is fundamentally wrong. That is, learning is not a simple linear addition of placing one concept or skill on top of another. Educators have traditionally assumed that schooling directly enables transfer of one topic to another, yet Berryman (1991) aggressively reports otherwise. She maintains that individuals do not predictably use knowledge learned in school in everyday practice, nor do they use everyday knowledge in school settings. Perhaps most important, learners do not predictably transfer learning across school subjects. Berryman writes that context is critical for understanding and thus learning. "[T]he importance of context lies in the meaning that it gives to learning" (p. 11). Furthermore, if learning is to happen "students must have the opportunity to actively use this information themselves and to experience its effects on their own performance" (Bransford & Vye, 1989, p. 188). If knowledge has no apparent application, it may not be perceived as meaningful or readily transferable to other learning situations (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990).

To the extent that schooling is isolated from the community (real life), too many concepts are learned in abstract ways. Learning theorists such as Berryman (1991), Resnick (1987), and Spiro, Coulson, Feltovich, & Anderson (1988) believe that transfer of knowledge is inhibited by learning environments which do little to address community based reality. Lave (1988) addresses this problem by advancing the concept of "authentic activity" which she defines as the ordinary practices of "just plain folks" within a given culture. Rather than using the educational syntax of the classroom, they propose using everyday activities as a means of providing contextualized or situated learning. This places learners in a free and more relevant classroom shared by a community of active learners.

Much learning takes place through social interaction, although it generally goes unnoticed. Rather than a classroom of individuals learning on their own, learning may be best accomplished through a small community of learners working together. For example, individual views regarding a particular topic are presented to the class, but later (i.e., after discussion and presentation of all the views within the community of learners) students are given the opportunity to revise their views. Any revisions reflect learning (a revision of thought processes). This means that the community of learners should be doing a lot of talking in an atmosphere based upon trust and mutual respect. The teacher's role shifts from the giver of knowledge to that of a facilitator who shares dialogue while challenging students to back up their claims.

All of this applies to the way educators within the field of technology education focus the curriculum. Current modes of delivering technology education curriculum activate certain aspects of learning theory but often come up short from delivering the total package. The modular curriculum which is so pervasive within the field today begins to address collaborative, "authentic" real world learning opportunities; however, it tends to be restrictive (limited in scope, collaboration, and sequence), disconnected (limited in transfer potential and unrealistic), and lacking a reality based learning context (hypothetically abstract). Rather than focusing in on the development of student learning skills, we remain enamored by the gadgetry of the technology itself. Rather than contribute to helping students develop the thinking skills where technology is used to solve problems within our society, we concentrate on the technical application of a few select technologies. Students are often left with minor technical skills and an unreflective assumption that all technology is good. Rather than help students develop a balanced perspective of the impact that technology has on society, we often present it as a power in and of itself that we as citizens have little or no power to control. Technology becomes this great sign of success and progress that is often beyond our ability to understand and therefore, must be accepted and applied simply because it exists rather than because it adds significantly to the society. As teachers of technology we can do more to aid students to become more proactive in the use of technology to solve problems rather than trainers of isolated technical skills.

Practice of Technology

The concern over technical skill development is another critical issue with regards to curriculum design in technology education. The debate over the types and degrees of tool skills associated with technology education continues to draw much concern throughout the profession. Current practices range from serious semi-vocational high-tech skill training to basic orientations with simple hand tools. The consternation that many technology educators experience with this topic has led to a polarization within the profession; the question over the types, quantities, and approaches used in the education about tool skills continues to loom over the technology education curriculum. Regardless of which philosophy is most appropriate in this matter, the need to address the practice of technology will remain as one of the constants within the curriculum, because this is one of the unique features of technology education. Perhaps a suitable solution to this dilemma would be to examine and coordinate tool skill development with *the processes used by technologists to solve problems* (e.g., learning technical design skills to help in the solution of a production problem). By doing this the tool skills would be serving a need rather than standing alone as unconnected activities within the curriculum. Technical skills have unique and historical roots within the field of technology education and industrial arts, classroom activities related to tool use have been an important motivator for many students over the years. It is literally impossible to address the study of technology in any practical terms without considering some application of tool skills. The critical issue is, to what degree should the curriculum be devoted to technical skill training? Historically, educators within technology education have given an exorbitant amount of instructional time to this area while slighting many of the other facets of the curriculum. An appropriate balance of tool skills with other curriculum areas is a key to a healthy curriculum.

Perspective of Technology

A missing link in our new curriculum is ‘perspective’. Perspective, in this case, indicates the need to examine - not just where we are and where we are going with technology - but where we have been. With current curricular approaches in technology education students will emerge with a lopsided view of reality if educators do not address the entire progression of technology: past, present and future.

The question of where to draw the line in the scope of studying the historical, present, and future issues within a given subject is often critical for teachers but according to Neil Postman, author of *Technopoly* (1992), this is of little importance.

> Perhaps the most important contribution schools can make to the education of our youth is to give them a sense of coherence in their studies, a sense of purpose, meaning, and interconnectedness in what they learn (Postman, p. 185-186). Postman continues, Modern secular education is failing not because it doesn’t teach who Ginger Rogers, Norman Mailer, and a thousand other people are but because it has no moral, social, or intellectual center. There is no set of ideas or attitudes that permeates all parts of the curriculum. The curriculum is not, in fact, a “course of study” at all, but a meaningless hodgepodge of subjects. It does not even put forward a clear vision of what constitutes an educated person, unless it is a person who possesses “skills.” In other words, a technocrat’s ideal - a person with no commitment and no point of view but with plenty of marketable skills. (p. 186)

Postman’s perspective of the historical component of education is essential to a complete understanding of present day conditions. The development of modern industrial societies was not possible without the evolution of technology. To truly educate students within our field the concept of technology’s history must be integral in the technology education curriculum. As Cicero put it, “To remain ignorant of things that happened before you were born is to remain a child.” According to Postman (1992) “every teacher must be a history teacher.” (p. 189) Without an understanding of the history of technology we as a society cannot completely understand or appreciate humanity’s confrontation with nature and learn of our limits with regard to nature.

So where do we draw the proverbial line between past and present? Is there, in actuality, a line to be drawn? At what point do we limit our curriculum perspective of technology? Why should our technological past be compartmentalized within our curriculum? These questions lead us to an understanding that technology is relative to time and culture, we can learn important lessons from the many technological developments of our past. This is wonderful food for thought and makes the study of technology thoroughly enthralling to students. Perhaps they will be the ones to answer some of the 'unsolved mysteries of the universe', if given an opportunity. Many educators would deem it obvious that to deny our technology education students a chance, through the curriculum, to delve into contrasting cultures of the past and present is pure tunnel vision. Cultural continuity gives sustenance to the study of technology.

Technology education aside from its more utilitarian, 'hands on' application is a valuable tool for discovering more about ourselves. Incorporating the technological process, in its entirety, into the technology education curriculum is essential for a far-reaching and quality program. It would be an incredible injustice to put limitations on our field of study, we need technology education to be comprehensive and stimulating.

Career Orientation & Awareness

Providing opportunities for students to be exposed to and learn about specific careers related to technology is an essential ingredient of the technology education curriculum. By presenting opportunities to experience technologies influence on solving problems, students are made aware of a variety of careers options. The question over what type of technological experiences to include in the curriculum has continued to be a point of concern for many technology teachers. Choices of technological topics vary drastically from program to program, with little attention given to the underlying needs for the experience (e.g., flight module - students learn basic principles of aerodynamics but seem to concentrate mostly on manipulating the flight simulator). A possible solution may be in an examination and implementation of content identified in the National Critical Technologies Report, a bi-annual report required by law and submitted by The Office of the President. The content of this report would provide an accurate, up-to-date analysis of the critical technologies that are impacting on the national economy and provide a strong basis for the technical and career options of the curriculum. This approach combined with local and regional career opportunities would begin to address some of the occupational needs of students.

Summary

It is difficult to determine the curriculum focus for technology education; the literature comprises a rather eclectic presentation of curriculum paths. Perhaps the most comprehensive plan for developing curriculum in recent times was identified in the *Conceptual Framework for Technology Education* (Savage and Sterry, 1991). However, even this model for technology education has not achieved universal acceptance and implementation within the field. The obstacles preventing the creation of a strong curriculum theory for technology education must be removed if the profession is attain the deep roots that are necessary to become a respected field of study. Current developments with the *Technology for All Americans Project* may help in creating this curriculum base for the field however, technology educators will need to address some very significant philosophical issues before this can happen.

The era of the independent technology teacher determining the content of curriculum based on personal interests is quickly becoming a practice of the past. As a unique field of study it is imperative that we understand the critical elements for our curriculum and then implement a convergent curriculum that addresses technology education comprehensively. To accomplish this we must be committed to confronting the following criteria.

1. Identification of curriculum themes based on what we really know about the study of technology, the processes used by technologists to solve problems, and the impact technology has on society. We must be able to get beyond our infatuation with the technical gadgetry.
2. An understanding of how people learn and discerning the most effective methods for utilizing this learning. Learning theory must be a strong focal point for the curriculum we develop for technology education. This may mean challenging and possibly changing some of our existing instructional approaches to better serve the learners.
3. Commitment on behalf of the entire profession (i.e., teachers, teacher educators, professional associations, administrators, supervisors, textbook publishers, equipment suppliers, etc.) to rethink, reskill, reorganize, and apply a thematically focused curriculum in the classroom.

The need for a curriculum focus will not be solved by select groups of educators working independently but will only succeed when the profession as a whole understands that a united approach to technology education is essential for a viable field of study. Technology education curricula has the potential to be strong and vital for all schools with many options available for teachers and students. However, the important component of curriculum focus is currently not targeted as definitively as needed for the profession to move forward vigorously to take its rightful place within the education community. If we are serious about making technology education a core subject in American schools then we must think about, plan, and implement our curriculum with consistency and focused vision.

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