Promoting Excellence in Preparation and Excellence in Practice

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Table of Contents

Volume XXVIII, Number 1, Winter/Spring 2002

As soon as the editorial process is completed, each article is posted online. As articles are added, the order and sequence in the Table of Contents and within the body of the journal may be changed to reflect and communicate the editor's concept and intentions for the issue and for this print version.

GUEST EDITARTICLE

ARTICLES

ARTICLES (continued)

IDEAS

TABLE OF CONTENTS

Guest Editarticle

Social and Professional Responsibility in Our Professions...or...*Pragmateia* in the Grand Scheme of Things

Ernest N. Savage

I've been a member of this honorary for over a quarter of a century, and I've often reflected as a trustee on the words of the three counselors while listening to the ritual, or while hearing a charge to the new members, or some words from members of the executive committee. Last year at the Mississippi Valley Technology Teacher Education conference I was honored to share a platform with a number of individuals who were addressing their involvement in some of the major initiatives in our field over the years. Ken Phillips, who was an original member of *A Curriculum to Reflect Technology* (Warner et al., 1947) team, spoke eloquently and respectfully of the contributions of W. E. Warner to that effort and many other initiatives in what we now may call Technology Studies. It struck me that, as you might expect, Warner's social reconstructionist philosophy found its way into the Epsilon Pi Tau ritual as Pragmeteia—social and professional proficiency—to think of professional and social needs first in order to live in peace and to assume an effective place in our society. In the grand scheme of things we might ask, How can we reconstruct our school and our profession in order to create a better society? The question is riddled with pitfalls, among them those value-laden issues related to what is a better society. Perhaps a bit more focus on the direction that Technology Studies is heading and the role of the profession in getting us there will be more manageable.

The Life Cycle of Technology Studies

If we look at a life cycle pattern containing seven stages—precursor, invention, development, maturity, pretenders, obsolescence, and antiquity (Rogers, 1995), we can clearly see the position of the old industrial arts as in the last gasp position of antiquity. But where do we see the new technology education positioned? Is it at the development stage where the program is protected and supported by doting guardians? Or has it advanced to the maturity stage where it now has a life of its own and has its place in the fabric of the internal and external community? Although I hesitate to speak the term aloud, could it be in the pretender stage, lacking some key element of functionality or quality? Where would you place our profession? For the sake of this article, I will assume that we have evolved only to the development stage and that there is still time and room for additional creation that could lead to even greater significance for the study of technology.

Our Social Challenge

Is there content in our field of study that would help all learners understand and work for peace in the world? Certainly the Technology Content Standards in the *Standards for Technology Literacy* (STL; ITEA, 2000) support that idea in providing a complete strand titled "Technology and Society" where four standards are devoted to that topic. It's interesting to note in retrospect that this project is a product of the Technology for All Americans Project. Isn't that part of our social problem today? While there are references to global issues in the documents, the overall project is a product of isolationism! On the flip side, it's the best document ever produced for our profession. Our challenge appears to be that we must become more global in our instruction and much more sensitive to the cultural and societal impacts of our technologies.

Input, Output, and Grouping

We have all been "content sensitized" to the point where when the STL came out we all jumped to chapter 7 to see if our favorite content area was represented. I'll not go there today. Rather, I'd like to talk about those inputs and outputs that should be fundamental to literacy in all learners. If that literacy is not addressed, the learning that occurs on the inside of our learning organization will not be equal to the learning that occurs on the outside of those organizations. That, according to Revans (1980), a pioneer in organizational learning, will result in the decline and decimation of the organization. The inputs have been aptly classified by the North Central Regional Educational Laboratory (NCREL, 2001) as digital-age literacy, inventive thinking,

This article is based on a presentation at the March 16, 2002, Epsilon Pi Tau International Breakfast held at the annual conference of the International Technology Education Association in Columbus, Ohio.

effective communication, and high productivity. The output of digital-age literacy is a compilation of "today's basics," basic, scientific, and technological literacy. Basic literacy, as has always been the case, incorporates the essential components of language literacy: reading, writing, listening, and speaking, but in today's context also includes the use of technology-based media. For example, do you listen to or read a book and do you read text off of an LCD screen, a page, or, in the near future, directly. Scientific literacy today relates more than ever to the synergy among science, mathematics, and technology. It must include a fundamental understanding of the bodies of knowledge of each of these disciplines as well as practice in the scientific method. Technological literacy, according to STL, is the ability to use, manage, assess, and understand technology. This level of literacy must include literacy in culture and global awareness. Cultural literacy assumes the ability to recognize and appreciate the diversity of peoples and cultures. Global awareness allows learners to understand and recognize the interrelationships among nation states, multinational corporations, and the people of the world. Digital-age literacy must, therefore, be contextualized globally and culturally. To do otherwise is to continue to perpetuate isolationism.

The outputs of inventive thinking are manifested in information problem solving and are operationalized by a person's ability to take into account contingencies, anticipate changes, and understand interdependencies within and among systems. They presume a person's commitment to lifelong learning by stimulating curiosity, creativity, and risk taking. Curiosity is a "desire to know." Creativity involves using one's imagination to develop new and original things, and risk taking involves taking a chance to lose something of worth for the opportunity to gain greater things. Other outputs of inventive thinking are higher-order thinking and sound reasoning. These outputs ought to be precursors to problem solving but often are dismissed as nonessential processes of the creative enterprise. In fact, higher-order thinking leads to informed, thoughtful opinions, judgments, and conclusions, where problem solving in isolation often leads to only one acceptable solution. The capacity to think logically in order to find results that meet appropriate criteria is a process of sound thinking and sound reasoning.

Another 21st century skill input is effective communication. This skill is sorely absent from the products of our high schools and university programs. Often our students have excellent technical capability, but they lack the social and personal skills necessary to be effective at many levels of enterprise. The outputs of this skill are teaming, collaboration, and the development of interpersonal capabilities. These outputs reflect the ability to work effectively as a member of a group of individuals who are dedicated to a common goal, to interact efficiently among the team, and to work in concert to achieve that goal.

The final skill output that NCREL addresses is high productivity. In some ways this is the 2000 version of TEXNIKH—skill in systems and processes related to information, organizations, and materials. These skills are soft and hard; a concept that we sometimes forget. Soft skills include the ability to carefully plan and manage work, concentrating on the main goal of the project while anticipating contingencies, to arrive at satisfactory results. Hard skills refer to the application of tools, materials, and machines to real world situations in ways that add value. Experience with high productivity skills provide students with insights across the domains of knowledge.

Mastery of 21st century skills requires the use of effective learning strategies, many of which have been alluded to already in this article. Specifically, social proficiency, or Pragmateia, must be reflected in the classroom through learning groups. Damian (2001) of ENC Instructional Resources has identified three learning group strategies that have implications for our field. Problem-solving partnerships allow students to apply their knowledge of mathematics, science, and technology principles to problems that could be encountered in life or work situations. Multiple approaches to solving the problem are encouraged, and individual students have the opportunity to explain and discuss their suggested solution. In cooperative teams a team plan of operation is created and goals are specified for highly structured teams. Team members share leadership roles within the framework of specific roles, while stressing cooperation in the achievement of goals. Collaborative groups allow for a high level of flexibility and creativity while allowing peer support and the opportunity to have extended amounts of time to think and work together. Garmston and Wellman (2000) identified seven norms of collaborative work: pausing, paraphrasing, probing, putting ideas on the table, paying attention to self and others, presuming positive intentions, and pursuing a balance between advocacy and inquiry. This type of behavior provides the "habits of learning" that could lead to a better understanding of culture and societies.

Collaborative work should also be a part of every teacher's portfolio. The National Science Education Standards (National Research Council, 1996) and the Principles and Standards for School Mathematics (National Council of Teachers of Mathematics, 2000) emphasize the need to establish collaborative learning groups for teachers as well as students. According to these standards documents, strong collegial support where teachers are working together to improve their own teaching skills and content knowledge results in systemic improvement and brings about a feeling of belonging and deeper meaning to the learning process.

"Leaning" Up the Profession

If our profession becomes committed to devoting more resources to Pragmateia-based initiatives, what will have to occur? We can look to the manufacturing enterprise for that answer in the "lean" movement. Lean organizations

- Accelerate improvements in speed and quality.
- Eliminate the "end of the month" crunch.
- Gain control and eliminate chaos.
- Earn performance recognition and rewards.
- Eliminate stressful work routines.
- Move from "fire fighting" to proactive problem solving.
- Contribute to improving the institution's bottom line.

Don't you sometimes feel like you're riding an old broken-down workhorse when other professionals are riding thoroughbreds? Perhaps it's because we operate in a manner that supports that kind of perception inside and outside of the profession. With all due respect to our associations and leadership, if we were to reflect upon becoming lean as a profession we might consider the following:

- Sharing the "technology" role. There is at least one state that is creating standards based on the following national standards:
    - National Educational Technology Plan
    - National Education Technology Standards for Students
    - Standards for Technology Literacy
    - Information Literacy Standards for Student Learning

  The thinking is that there is plenty of content to go around. What is important is that students meet the outcomes.
- Changing the name of the profession. We've done this before, but we may have missed the mark. I'm aware of confusion on virtually every standards committee, whether at the local, state, or national level where there is misinterpretation between technology education, educational technology, computer technology, and information technology. If we aren't going to embrace the approach identified by the first bullet, we should consider changing the name to something more descriptive such as Technology Studies. It works for Social Studies!
- Unify the profession. This is, of course, heresy in the cathedral. However, the more associations that we have representing us, the more diluted our message becomes, and the less strength our representative bodies have, sometimes all the way down to the local level.
- Make a commitment to standards. Regardless of the standards selected, the process used to create these documents is accountable and defensible. As we become more committed at a national level to the linkage of funding to assessment, it will be necessary to link our outcomes to valid documents.

If we were required to take an oath upon becoming teachers, would it include "advancing understanding, appreciation, and awareness of technology as both an enduring and influential endeavor and an integral element of culture?" I would hope so. We all believe in this statement because it is the last statement in the Code of Epsilon Pi Tau. Through this is our opportunity to go far.

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Samson's Hair: Denuding the Technology Curriculum?

James G. Edwards

The biblical story of Samson (Judges 13–16) tells of a bold, super-strong hero of his people who was compromised when his hair, the source of his supreme strength, was cut off while he slept. What is occurring in the technology curriculum in the United States may indeed parallel the Samson tale. For, in spite of glorious concepts, relevant content, and ambitious standards, its effectiveness may be compromised. It appears that the curriculum's "Samson's hair," activity that includes hand skill development which, for so long, has been the source of its uniqueness and strength, is being diminished. Regrettably, this important element is totally nonexistent in some technology instruction. In the face of this circumstance, I argue that efforts should be undertaken to ensure that the imaginative curriculum change that is underway integrates and includes, wherever possible, true activity that includes hand skill development.

To consciously and conscientiously include hand skill development in technology courses will continue a unique and distinctive approach to activity learning that was evident in industrial arts. That approach contributed powerfully and positively to individual learning and student development. Inclusion of that element in technology courses today will ensure delivery of instruction that benefits students in a way that is not achieved in other school subjects because it will:

- Maintain the interest of students to a greater extent than occurs in most other subject areas.
- Respond to learning styles that the instructional devices commonly used in other subject areas do not do.
- Make a contribution to students' cognitive development in a manner not enjoyed by virtually every other subject area in the schools.

With hand skill development, pursued consciously and effectively, the technology curriculum will reflect unique but important qualities, as did industrial arts. Thus, in response to the industrial age, the content of manual arts and manual training programs appropriately responded to changing societal and human needs. But activity and hand skill development, practiced in the curriculums being replaced, were maintained.

Now, technology curriculum efforts are responding to the information and computer age in the same way that industrial arts upgraded the manual training and manual arts content to respond to the industrial age. Interestingly, while we have learned more about the efficacy of activity and hand skill development, technology curriculum developers seem to have chosen not to follow the industrial arts approach to changing content while maintaining the efficacious part of the methodology.

A well-founded fear is that although the new standards characterize the new direction as an activity curriculum, the nature and structure of the laboratory settings, learning activities, and equipment in the laboratory settings result in a dearth of learning experience that include true hand skill development.

Thus, we may be witnessing noble and efficacious curriculum content and concepts promulgated and implemented without that element that may be considered the most important and beneficial learning aspect that our field has to offer. If this is true, then it is appropriate to challenge leaders to ensure that the new technology content is organized and delivered so that hand skill development remains prominent.

I assert that the lack or diminution of hand skill development in our schools limits the student's engagement in the active learning process and retards the student's growth and development. Thus, my challenge is that leaders should bravely draw upon, integrate, and ensure that the heritage of the rich, unique, and educationally viable industrial arts learning and instructional method that included hands skill development will be carried forward and be pervasively evident in the new curriculum.

While the preceding outlines today's situation in general, I offer some specifics in the three following parts: First, I relate our heritage as imbedded in the views of an early industrial arts leader. The second part reviews statements regarding that heritage made by contemporary leaders who support activity and hand skill development. The third part is

The ideas in this article are drawn from the author's address at the Epsilon Pi Tau Breakfast at the California Industrial and Technology Education Association Conference, March 11, 2000, Pasadena, California.

devoted to the views of an eminent neurologist who elaborates the importance of hand skill development in his recent best-selling book. Finally, I take the liberty to follow-up and conclude with a summary that reiterates the critical need to include hand skill development activity in the technology curriculum in order for that curriculum to serve the needs of students and continue in American public schools.

Frederick Gordon Bonser's Views

We travel 90 years back in time to trace the recognition of the strength and importance of hand skill development in industrial arts instruction. The historical roots are found at Columbia University with the '"father" of industrial arts, Dr. Frederick Gordon Bonser.

Born on June 14, 1875, on a farm in Pana, Illinois (Bawden, 1950), Bonser's early life was filled with doing chores and learning the hand skills necessary for working on a small farm. There were no schools in Pana, and when he reached high school age Bonser moved 160 miles from home to attend high school. After high school he attended the University of Illinois and completed his bachelor's degree in psychology in 1901 and a master's degree in 1902. In 1905 Bonser received a graduate fellowship to Teachers College, Columbia University, where he completed his doctorate in 1906. After teaching in the field for three years, Bonser received an appointment to Teachers College, Columbia University, as head of the newly formed Department of Industrial Education.

In 1912, Bonser and James Russell, dean of Teachers College, published a pamphlet that focused on the introduction of the industrial arts hand skill development curriculum as a way to reform education. This landmark publication emphasized the importance of the hand and the mind as co-equals in education of all children.

Bonser believed that hand work was not just for the development of a skill, but was a means of developing understanding and attitudes (Russell & Bonser, 1912). He also believed that hand skill development was a means of satisfying the constructive impulses of the learner and that all students would benefit from the development of "general dexterity and control appropriate for normal physical growth and general life participation" (Bonser, 1932, p. 158). He emphasized that "the industrial arts as a study utilize hand work as a means to help in developing meanings and values, as a way of clarifying ideas and cultivating appreciations" (Bonser, 1932, p. 203).

Some years later, Bonser (1932) advocated that the purpose of hand skill development of industrial arts was to "bring more meaning to life. Hands would be used, true enough, but as the willing servants of a better and finer mind and soul" (p. vii). He also supported the importance of his view by the conjecture "as if something good could be done by the hands apart from the mind and soul" (p. viii). With these statements Bonser focused on the integration of hand work into all aspects of education.

It should be added that as an early advocate of the hand and the brain as co-creators of the young person's perception of meaning and value in life, Bonser said:

> The use of the industries is basic as a material out of which and up which to build that culture of hand and brain and soul which make the individual alert, inventive intelligent, appreciative, and moral in any vocational activity which either choice or circumstance may impose. (Russell & Bonser, 1912, p. 36)

Bonser (1912) asserted that culture "that is genuine" (p. 36) is founded upon and vitally involved in utilitarian activities. His vision of hand skill training and its role in education was of two parts. The first part emphasized the importance of hand skill training as a means for having a fulfilling life. In this regard his vision supports the unit shop of industrial arts. However, the second part of his vision emphasized the importance of hand skill training as an integral part of every child's education. In this regard his vision more closely supports the underpinnings of today's technology curriculum.

Contemporary Leaders' Views

Technology education must return to and embrace hand skill development as equal to, and integrated with, its own module curriculum if it is going to be of strategic importance in the new century (Foster, 1994; Herschbach, 1997; Petrina & Volk, 1995; Volk, 1996).

In 1994, a paper published in the *Journal of Technology Education* argued that technology education has drawn its philosophical base from industrial arts and it follows that hand skill development should be included (Foster, 1994). Two years later, a second paper in that journal (Volk, 1996) argued for the recognition of "the value of hands-on creative and design process" (p. 35) of the industrial arts curriculum and acknowledged its value as equal to technology education. Petrina and Volk (1995) and Volk (1996) suggested that the problem is that technology education has rejected its historical roots—industrial arts.

Many researchers have reported that the strength of the industrial arts curriculum is its ability to engage the learner in individualized projects that require hand skill development (Jewell, 1995). Volk (1996) suggested that hand skill development is the "hidden curriculum" and the "real strength and true value of industrial arts programs" (p. 34).

In a presentation to the 85th Mississippi Valley Technology Teacher Education Conference, Karnes (1999) reported on a question he posed to leaders in the field: "What are the most critical changes or improvements which must be made if technology education is to be an integral component of strategic importance in the total educational enterprise of the new century?" (p. 11).

He received and reported on responses from 35 distinguished leaders in our profession (Karnes, 1999). Five papers touched on the contribution of the industrial arts curriculum and hand skill development. One recommended that the foundation of the new technology education curriculum is the history of industrial arts (Barnett, 1999). A second recommended that students learn best when "actively engaged in meaningful activity" and that this activity must have a "hands-on orientation" (Custer, 1999, p. 17). A third asserted that we must not forget that "we teach skills as an integral part of technological knowledge" (Lux, 1999, p. 22). A fourth paper argued that hands-on, realistic experiences with tools, materials, and processes are the methodology of the field (Moss, 1999). Buffer (1999) offered strong support for both Bonser's and Wilson's attitude toward activity and hand skill development (my detailed discussion on Wilson is in a following section).

Buffer (1999) remonstrated that the leadership of technology education must remember their historical roots and focus on a new mission and new goals that embrace the principles of industrial arts and hand skill development. He asserted, as did Bonser in 1912, that technology studies must be a "viable and integral component of our educational fabric" (p. 15) and relevant to the social, economic, and political well-being of the students. He closed by pointing out the importance of hand skill development and technical knowledge: "Students need to have experiences with real tools, materials, equipment, and processes in laboratory settings that enable them to achieve technical skills and competencies to solve problems confronted in daily life experiences" (p. 16).

As the new technology curriculum continues to grow and expand, as it ought to, we can only hope that those who write and implement the curriculum heed the wisdom of Barnett (1998), Bonser (1932), Buffer (1998), Custer (1998), Foster (1994), Herschbach (1996), Lux (1998), Moss (1998), Pertina (1995), Volk (1996), and many others and include hand skill development as co-equal with mind development.

The curriculum developers and implementers and the teachers may appreciate the preceding statements from historical and contemporary leaders. They will be persuaded further by Frank R. Wilson's views about hand skill development.

A Neurologist's Views: The Thoughts of Frank R. Wilson

Interestingly, like Bonser, Wilson is an alumnus of Columbia University. His book, *The Hand: How Its Use Shapes the Brain, Language, and Human Culture,* published in 1998, defines his vision about the importance of the hand in daily life. Wilson identifies recent discoveries and research that provide support for Bonser's vision including: "It may also be that the most powerful tactic available to any parent or teacher who hopes to awaken the curiosity of a child, and who seeks to join the child who is ready to learn, is simply to head for the hands" (p. 296).

Wilson is a neurologist and the medical director of the Peter F. Ostwald Health Program for Performing Artists at the University of California School of Medicine, San Francisco. In spite of the program's title, Wilson is a neurologist to all occupations who have problems with their hands. He serves performing artists who have serious hand complications and can no longer play their instruments. He serves teachers with hand damage who want to return to the classroom and write well. He serves writers who have chronic writer's cramps and also plumbers, carpenters, auto mechanics, and computer programmers who are having trouble with hand control.

The 1998 book reports the results of 15 years of research. Wilson began his research with a plan to identify how the brain controls the hand. Through his extensive research and interviews, he found, to the contrary, that the hand not only controls a large portion of the brain but also actually trains the brain and creates value for it.

Wilson argues that the hand has shaped our development cognitively, emotionally, linguistically, and psychologically. In support of this view, he shares recent compelling research in anthropology, neuroscience, linguistics, and psychology and the results of personal interviews with 27 professionals who depend on the use of their hands for the fulfillment of their life's work.

Anthropological research, according to Wilson (1998), suggests that the brain tripled in size in response to the developmental requirements of the hands, arms, and shoulders. He cites research that demonstrates how the bones of the hand, arm, and shoulder are not connected in a physical joint but are suspended in position by a complex network of muscles, membranes, and ligaments. This complex network instructs the brain on how to follow so that a finger extended can move and land at an exact point that may or may not have been visually identified. The hand can accomplish this, over and over again, with great accuracy and without the conscious awareness of the other one third of the brain.

Wilson (1998) further asserts that the fingertips are the most sensitive part of the body. The fingertips can describe to the brain the unseen nut or bolt as the skilled auto mechanic removes a small part. Upon repair of the removed part, the hand working in concert with the brain brings the part accurately back into a hidden position that can be around a corner, up a bit, and angled to the left. The hand can do all this with the accuracy of the violinist or with skill of the surgeon because two thirds of the brain has "pre-wiring" (p. 125) that serves as a blueprint for the development of hand skills. This pre-wiring remains dormant until the hand skills are developed and becomes active once the hand skills are developed. The information, which is coming from the hand, is automatically processed in the brain and brings meaning and value to life experiences. Without the awakening of the hand skills and the pre-wiring in the brain, the meaning and value will remain unknown and out of reach.

Wilson (1998) makes the fascinating point that the hand talks to and develops the brain as much as, or even more than, the brain dictates to the hand. He argues, as Bonser did, that to ignore and not to integrate hand skill training of the individual into the school curriculum creates an educational process that is "grossly misleading and sterile" (p. 7). He calls for the understanding, integration, and acceptance of hand development as central to human culture and a "basic imperative of human life" (p. 10). The educational system, he suggests, "should accommodate the fact that the hand is not merely a metaphor or an icon for humanness, but often the real-life focal point—the lever or the launching pad—of a successful and a genuinely fulfilling life" (p. 277).

The premise for Wilson's (1998) book is that the hand is at the core of human life as much as the brain. He also asserts that because of the central role of the hand in bringing meaning, understanding, and value to one's life that hand development is as much about intelligence and intellectual thinking as the brain.

Wilson (1998) has found that many young people are gifted at using their hands—they can build and fix complicated things in everyday life. He points out that often these same students have difficulties in learning when the hand is not involved. He asserts that we must come to understand that there are two kinds of intelligence: the hand as "hand knowledge" represents one and the other is represented by the brain as "symbolic knowledge." He asserts that the two should be integrated and that both are equally powerful in leading the student to a meaningful and successful life. However, he maintains that the intelligence of hand knowledge is not equally appreciated when it comes to the praise and reward systems of our schools. Wilson recommends that educators should find ways to explore and to integrate into their curriculum the "interaction of intelligence-as-information [book and language based knowledge] and intelligence as action [hand-skill knowledge]" (p. 284).

Destroy the Temple?

Readers will recall that in the Bible story Samson regains some strength from a slight regrowth of hair. In spite of the fact that his enemies had blinded him, he induces someone to lead him to the central pillars of his enemies' temple. His last act in life is to find the strength and energy to move those supports and the temple is destroyed. We could take the analogy a bit farther and urge the field to build upon the small amount of true activity and hand skill development that exists in some technology courses. When it succeeds to completely reintroduce hand skill development, the technology curriculum will enjoy a strength and attractiveness that will result in its wider adoption and that will endure. Or, we could learn from Samson's blindness. It did not stop him from achieving the objective of destroying his enemies. But, in the case of the technology curriculum, blindness to the importance of activity that includes hand skill development may be akin to pulling the temple down upon the field.

Could some future historian of education point out that leaders of a most vital curriculum denuded that curriculum of its salient contribution of hand skill development integrated with activity? Could the historian write that in response to the changing needs of the population and society those leaders created intriguing and highly popular curriculum materials and conceptualized their delivery in laboratories that were appealing and *a la mode*? Could that future observer go on to say that while they spoke of "activity," it was not the historical and tried and true hand skill development activity of industrial arts? And is it possible that the writer would conclude that with the uniqueness lost, the teachable moments in the curriculum they developed could then be done by others such as science, mathematics, or social studies teachers.

I hope that that scenario will never occur and that we will endeavor not to "cut the Samson's hair" from our curriculum but ensure that all our curriculum efforts and all our modules and all our new laboratories will provide, in as many cases as possible within the curriculum, the "Samson's hair" of our field—activity that includes hand skill development with tools and materials. In this regard and as a segue to my close, I share a message from one teacher to another. After all, I quoted a number of leaders, all of whom did or are operating at the university level.

Now let me draw from a true leader who is doing the curriculum. He is in a position to really know. Following is a message to a fellow teacher from Joe Leogrande (personal communication, March 27, 2002), a highly successful middle and high school teacher and the newly elected president of the New York State Technology Education Association:

> [Yes...] RJT, Lab Volt, Hearlihy, Paxton-Patterson modular technology labs and others like them are very well-developed curriculum [materials] provided the students can read manuals, and assemble prescribed projects. As you mentioned, authentic assessment activities where students design, draw, construct, test, optimize, test, and present, are the most valuable. A blending of lab and authentic assessment activities are the best solution, and Sayville Middle School, which was program of the year in 2001 does just that. They have a computer lab and a "shop" to combine their activities. Yes, students who just sit at computers and build or just simulate real stuff will not do as well on the assessment since all the standards of tools and resources are not being covered, and no saw dust will ever be in the cuffs of kids.
>
> My friend from Sodus Middle School just installed a computer-based tech lab, and he feels sorry that his students will never touch a band saw or sander in middle school, they will just see and hear a simulated version of them on a computer.

There is a danger to be avoided. We ought to ensure that students are not considered to have completed a course in technology that is devoid of real and meaningful hand skill development opportunities. Those of us who plan experiences that may include work with modules, kits, and computers ought not accept the hand work associated with those elements as equivalent to the true hand skill development experiences that would have been acceptable to Bonser in his lifetime and accepted by leaders in the field today and to Wilson. The changed nature of the content is not an excuse to cast hand skill development out. Rather, if the new content is to be offered and be meaningful, the challenge to the developer is to discover, create, and implement learning experiences with the new content that provide hand skill development opportunities. For, if anything can be learned from the tour that I have taken with you, dear reader, is that the content of the field is fleeting and is likely to remain so. But the real contributions to student growth have come from the field's unique instructional methods, its activity base and hand skill development. That fact, along with the realization that those are the enduring aspects, should guide curriculum and instructional development efforts. We owe no less to our clients.

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Technology Transfer: A Third World Perspective

Anthony I. Akubue

The application of technology to stimulate development in the Third World received unqualified endorsement and support after World War II. In the postwar period from the late 1940s through the early 1960s in particular, a great number of former European colonies in Africa and Asia emerged from the bonds of colonialism to become independent countries. The acquisition and application of technology was considered integral to accelerated development in the newly independent nations. From a classical economic standpoint, development was synonymous with economic growth and industrialization was essential to that growth. Thus, to industrialize, capital accumulation, infrastructure development, foreign technical experts, and the importation of modern technology from the industrialized countries were deemed indispensable. Each newly independent country opted for a strategy of industrialization deemed appropriate for its national development goals. Depending on those goals, a country adopted either an import-substitution industrialization (ISI; to enable the country to manufacture goods that were previously imported for domestic consumption), an export-oriented industrialization (EOI; to enable the country to manufacture goods for export to other countries), or a combination of both. Regardless of the strategy adopted, implementation invariably required the importation of capital goods (that is, machines, equipment, and plants) and the development of national infrastructure for domestic production of manufactured goods. The importation of technology or the so-called transfer of technology from the rich to the new nations that ensued, especially from the mid-1960s, was intended to spur development through industrialization. Thus the development of the Third World for all intents and purposes was linked with the acquisition and utilization of technology from advanced Western countries.

Decades of technology transfer have not produced the expected outcome, considering the dismal social and economic conditions in many Third World countries today. The anticipated transformation in the economies of Third World countries has, so far, been elusive. What went wrong? Why has the outcome of technology transfer to the Third World been so disappointing? What is technology? What is technology transfer? Is technology transfer to the Third World what it should be? Under what conditions can the transfer of technology stimulate innovation and development in the Third World?

We in the technology education and allied professions contribute significantly to the technological and socioeconomic development of the Third World. Graduates of our programs are successfully developing and implementing technology education programs in an increasing number of Third World countries. We also contribute through the scholarly work we undertake in some Third World countries from time to time. Our professional conferences and journals, where papers such as this are presented and published, disseminate useful information for use in the Third World. Suffice it to say that in our profession we take pride in making a difference worldwide.

This article discusses the issues raised in the preceding questions concerning technology and its transfer to the Third World, specifically, the current practice of technology transfer and how it can be made more effective in stimulating development in the Third World.

Technology Transfer to the Third World

As many in our profession know, technology encompasses both material and nonmaterial components. That said, perceptions and assumptions about technology can and do affect the outcome of its transfer. A popular perception of technology is that it comprises physical devices. However, the problem with equating technology with physical objects is that so much is often assumed away. It is often assumed that if a machine or a "technique of production" works perfectly well in the country and circumstances in which it was created and nurtured, it ought to do just fine in any other locale. First, technology does not function in a social vacuum as this line of reasoning seems to suggest; it depends on factors such as the prevailing social relations, physical as well as human infrastructure, and raw material availability. Second, the suggestion is also made that the transfer of technology provides all that Third World countries need for technological, social, and economic development when these countries receive machines or techniques of production from the advanced countries. This notion of technology transfer is overly exaggerated and sanguine. It is even false, because several implied elements have no basis in reality. It is not true that Third World countries have no problem absorbing transferred technologies, that adaptations are not required, that all companies remain equally efficient, and that firm-specific learning or technical effort is unnecessary and irrelevant (Lall, 1992).

Indeed, capital goods embody, but do not by themselves constitute, technology; they are products or object-embodied technologies that can be purchased freely on the international market. If the import of such means of production were all that was necessary, many Third World countries would be as industrialized today as their counterparts in Europe and North America. Saudi Arabia can be used to illustrate this point. With all its oil wealth and billions of dollars in foreign reserves, Saudi Arabia is able to buy sophisticated machines and equipment from Europe, North America, and Japan; however, the country's telephone system, for instance, remains comparatively second-rate. The transfer of technology entails much more than the mere acquisition of physical assets. The purchase of a house, for instance, does not constitute a transfer of the architectural and construction knowledge and skill that went into its establishment. The technology transfer process is more like learning carpentry than purchasing a new drill. "If one does not develop the skill to use the tool adeptly, and if one does not understand how one particular stage relates to other stages of production, one's product will be inferior and not sell" (Mittelman & Pasha, 1997, p. 61). By the same token, the purchase and possession of a machine or equipment by a Third World country neither bestows upon the people of the country the scientific and technological knowledge essential to its production locally nor the ability to set it up for efficient production. In fact, it is often the contention that material-transfer is not actually a form of "technology" transfer. According to this school of thought, the important ingredient in material-transfer "is not 'know-how' but 'show-how' and the core technologies are embodied within the physical items" (Simon, 1991, p. 8). Emmanuel (1982), an adherent of this school of thought, argued similarly that the export of a machine "rather constitutes a substitute for the transfer of the technology which would have been necessary in order to produce it locally, and is a sort of non-transfer" (p. 22).

Nevertheless, most models of the technology transfer process do seem based on across the board assumptions that do not reflect current realities. The models are usually based on ideal conditions for technology transfer where transactions involve equally endowed senders and receivers of technology. In other words, no distinction is made whatsoever between senders and receivers of technology. Thus, Third World countries are expected to possess the capacity to integrate imported technology into production processes on their own without needing assistance. As Stolp (1993) pointed out, "this perspective places the recipient and its capacity to absorb new technology on an equal conceptual footing with Northern senders of technology" (p. 156). It is rather obvious that this is certainly not the case. Whereas the transfer of technology involving two firms from two technologically advanced countries often results in mutual benefits and technological interdependence between the participants, the same cannot always be said about transactions involving industrialized and Third World countries. A strategic alliance involving Motorola of the United States and Toshiba of Japan illustrates this point. In this alliance, Motorola exchanged its microprocessor technology with Toshiba for the latter's memory technology. In addition, Toshiba also agreed to assist Motorola in expanding its sales into the Japanese electronics market (Simon, 1991). This is typical in most strategic alliances, where the critical and determining factor is the existence of parity in the benefits that each firm derives from the transaction. That the transfer of technology between two firms from industrialized countries is mutually beneficial to the firms can be attributed to their superior scientific and technological knowledge, which constitute the basis for the development of capital goods and related physical structures. The successful economic recovery of both Europe and Japan after World War II, with the help of the U.S. Marshall Plan, is another event that illustrates this point. Those who equate technology with physical structures believe that the fast recovery of Europe and Japan was an "economic miracle." The truth is that physical structures constitute only the visible character of technology or, metaphorically, a tip of the iceberg. The submerged base of the iceberg or the invisible aspect of technology—knowledge, skills, and organization—remained intact after the physical industrial structures were smashed to pieces during World War II. It was this invisible form of technology, of which people are the carriers, which enabled the countries to rebuild their economies as rapidly as they did after the war. Europe and Japan possessed an absorptive capacity lacking in most Third World countries and were able to rebuild once they received Marshall aid funds (Aharoni, 1991).

Technology "transfer connotes the movement of knowledge, skill, organization, values and capital from the point of generation to the site of adaptation and application" (Mittelman & Pasha, 1997, p. 60). It is the useful exchange of ideas and innovations enabling the receiving region or country to expand on and utilize the knowledge received. This means that technology transfer also includes the knowledge of getting things done (Ofer & Polterovich, 2000). A critical test of technology transfers, therefore, is whether they stimulate further innovations within the recipient country. It is wrong to see technology transfer as an end in itself; rather, its importance derives from its ability to stimulate and strengthen the innovation process. In other words, it is an avenue with a great potential to increase the rate of technological innovation (Osman-Gani, 1999). For instance, the transmission of information about the invention of gunpowder and some basic gun-like devices in China stimulated the invention of the formidable cannon in Europe. Information about transistor technology from the United States provoked the development of new kinds of consumer products in Japan (Pacey, 1990). This is not happening in Third World countries to the extent expected despite decades of massive importation of object-embodied technologies from the industrialized world.

The intent here is not to imply that capital goods are not important. On the contrary, investment in capital assets is an indispensable prerequisite of economic growth. However, the primacy of people as the ultimate basis for the wealth of nations is indisputable. As the active participants in any economy, human beings accumulate capital, exploit natural resources, build social, economic, and political organizations, and affect national development. Capital and natural resources, on the other hand, are passive factors of production that depend on human manipulation to be useful. In other words, the development of a nation significantly depends on the skills and knowledge of its human capital.

The point is that many Third World countries are not developing the human as well as the physical capital that they need to build and enhance the national stock of capital. Domestic capital development and investment is essential to a country's income generating capacity. Foreign ownership of capital has served foreign investors well, enabling them to repatriate large amounts of income or profit abroad at the expense of the host Third World countries. Aggarwal (1991) identified the direct or first order costs associated with the disadvantages of technology transfer to Third World countries vis-a-vis the transferring firm to include the "outflow of dividends, profits, management and royalty fees, interest on loans, and other remittances by the firm including the possible use of high transfer prices" (p. 69). The transfer of technology as we know it has neither engendered domestic expansion of innovations nor done much to promote indigenous human as well as material capital development in most Third World countries.

When a country cannot on its own exploit imported technology to improve domestic production, let alone learn from it to further domestic innovation, it is inappropriate to speak of a transfer of technology taking place. The capacity to assimilate, adapt, modify, and generate technology is critical to an effective transfer of technology. It is perhaps appropriate to note the deficiency of the phrase "technology transfer"—it suggests a process in which the recipients of a new technique passively adopt it without modification. Pacey (1990) suggested differently: "transfers of technology nearly always involve modifications to suit new conditions, and often stimulate fresh innovations" (p. 51). The capacity to make necessary adjustments to imported technology requires a superior level of skill, knowledge, and expertise of the recipients.

Without the benefit of absorptive capacity mostly achieved from *capacity-transfers*, Third World countries cannot take advantage of the preponderant power of technology as an effective means of fostering sustainable socioeconomic development. The concept of absorptive capacity is not limited in meaning only to the acquisition or assimilation of knowledge, but also includes the ability to exploit it. The concept is similar to what the United Nations terms indigenous technological capability (ITC), which has to do with the knowledge and skills of a country's human capital, and other absorptive provisions such as infrastructure, raw materials, and such things as the nature of the soil and climate. Among the attributes of a society with ITC are: an understanding of its technological needs; an effective policy on technology and its acquisition; effective global scanning and search procedures for identifying and selecting the most beneficial technology and supplier; the ability to evaluate the appropriateness of the technology to be imported; a strong bargaining or negotiating expertise needed for technological acquisitions; technical and organizational skills to use imported technology; the ability to adapt imported technology to local conditions; the availability of requisite infrastructure and raw materials; and the capacity to solve its problem using its resources. According to the United Nations (1983), ITC is not an alternative to a successful technology transfer but a necessary condition for it. The difficulty that most Third World countries face in trying to build their ITC can be blamed on internal as well as external obstacles.

Obstacles to Building Indigenous Technological Capability (ITC)

Third World countries have relied heavily on industrialized world sources for the acquisition of technical knowledge and skills. Those involved in the export of technology from industrialized countries are individual entrepreneurs, nongovernmental organizations (NGOs), government agencies, multilateral agencies, religious organizations, foundations, universities, consulting firms, and, of course, multinational corporations (MNCs). In terms of the magnitude of activity undertaken, MNCs, described as the most prolific purveyors of technology transfer (Simon, 1991), are by far the dominant group. They own and operate multibillion-dollar research and development facilities for generating new knowledge and innovations. The resulting knowledge and innovations are protected under lock and key within the confines of the MNCs. The extent to which MNCs transfer or provide technological knowledge and innovations to Third World countries remains open to debate. It is no exaggeration that the vaunted transmission of technological knowledge and innovations by MNCs often is a carefully monitored flow from corporate headquarters to the premises of a subsidiary in the Third World (Mittelman & Pasha, 1997). In fact, the activities of most MNCs may be described as guided primarily by the profit motive. It does not come as a surprise to anyone that MNCs do not operate with the objective to intentionally transfer innovative capacity to the Third World. In fact, Mittelman and Pasha (1997) observed that "the transfer of technology, to the extent that it actually occurs, is nothing other than leakage from [M]NCs" (p. 63). In other words, MNCs are not into capacity-transfers to host Third World countries. Ironically, capacity-transfers are the most coveted category of technology transfer that can lead to the development of absorptive capacity in Third World countries. According to Osman-Gani (1999), capacity-transfer "involves the transfer of knowledge and the capability to develop new technology" (p. 4). As critical as capacity-transfers are to the development of absorptive capacity, it is easy to understand why MNCs generally will not willingly transfer such capabilities outside the confines of their own organizations. It is naïve to expect MNCs to work willingly to build the self-reliance of countries that constitute a very significant source of corporate profits.

Similarly, bilateral and multilateral assistance to Third World countries is not, as most people would believe, an act of charity. It has been said that aid actually inhibits forms of development that do not suit the donor (Mason, 1997). This statement cannot be entirely false, especially knowing that government-to-government assistance without expecting something in return goes against the fundamental law of economics that "there is no free lunch." Foreign aid was intended to accomplish two major purposes:

> to ensure that the economies of the Third World functioned efficiently, because the prosperity of the West was closely connected to the purchasing power and raw materials of the non-West; and, just as in Europe, to discourage the development of national capitalism or communism in any form. (Mason, 1997, p. 433)

This is not an attempt to diminish the value of foreign aid. The point, however, is that foreign aid seldom happens without strings attached. It is hardly a secret that foreign aid has helped create foreign appetite in the Third World. Not too long after World War II, most Third World countries could feed themselves, but that is hardly the case anymore. Mason (1997) noted, for instance, "As a result of U.S. food aid policies, recipient countries were forced to modify both their own food policies and the eating habits of their people" (p. 431). The beneficiaries of this turn of events were most U.S.-based multinational agribusinesses, U.S. farmers, and consumers. Today, in the Third World "local peoples largely produce what they do not consume and consume what they do not produce" (Mittelman & Pasha, 1997, p. 47). Thanks to sophisticated communications and transportation technologies, the Third World is no longer shielded from the global wind of change ushering in what Mason (1997) termed "'McWorld,' a gustatory metaphor for globalization" (p. 408).

However, the impediments to technological development in the Third World are not all externally induced. Reluctance on the part of Third World elite to undertake the educational and technological effort needed to gain mastery over technology is also a part of the problem. Believing the acquisition of machines and other technical devices to be their priority, Third World countries embarked on a massive but passive importation of technology. Today, the landscape of most Third World countries is littered with expensive machines and construction equipment that are rusting away due to scarcity of spare parts and lack of maintenance. The literary educational curriculum inherited from past colonial administrations has not been changed or adapted to address the technological and socioeconomic needs of most Third World countries. Technical, technology, and vocational education are regarded to be less in importance relative to literary education. In fact, graduates of technical and vocational education are often looked down upon as individuals without enough brainpower or mental aptitude for literary education, who are, therefore, routed to the less prestigious technical schools. In other words, they are rejects of literary education (Akubue & Pytlik, 1990). The ambition of most Third World youth to work in air-conditioned offices just like the former colonial administrators, themselves graduates of literary education, can be attributed to the assimilative effect of colonialism. Until they see fit to develop educational systems that address their particular needs and develop a sense of their true priorities, Third World countries will continue to lack the absorptive capacity to utilize technology to foster their development and raise the general standard of living. This is a point that is supported by the many years these countries have tried to take advantage of different mechanisms of technology transfer to no avail. Mechanisms of technology transfer are vast and varied, including direct foreign investments, joint ventures, licensing, training, commercial visits, print literature, the Internet, sales of products, turnkey projects, and so on. Some of these are discussed in the next section.

Mechanisms for Technology Transfer

Due to the constraint of space only four of the major modes of technology transfer are discussed here; namely, foreign direct investments, joint ventures, licensing, and turnkey projects.

Foreign Direct Investments

Foreign direct investment (FDI) is one of the more frequently used channels of technology transfer. An FDI is usually a long-term productive investment in foreign countries in which an investing multinational corporation exercises either full or partial management control of assets and production in the countries involved (Mallampally & Sauvant, 1999; Siddiqi, 2001). To attract FDIs, Third World countries are promising policy liberalization, political stability, privatization, and minimal government intervention. Where all or a portion of these conditions are assured, a foreign corporation may be motivated to set up production facilities in a Third World country. Among other things, multinational corporations invest in the Third World to protect an existing market or to create a new one, to bypass prohibitive barriers and import restrictions, to discover or protect raw material sources, to renew a product's life cycle, to take advantage of cheap labor and skills, and to increase profits (Kaynak, 1985). Opinions differ as to the benefits of FDI to the Third World. While some argue that benefits include transfers of production technology, managerial expertise, skills, innovative capacity, and increasing access to global markets, others are less convinced and argue that any transfers to the Third World as a result of FDIs are mainly unintended leakage (Mittelman & Pasha, 1997). Whatever the argument, it is doubtful, from decades of experience, that FDIs are a significant source of capacity building and national capital formation in host Third World countries.

In any case, FDIs are once more in high demand after the setback in the 1970s when a number of Third World governments nationalized many foreign firms after accusing them of exploitation and excessive profit repatriation. It has to be pointed out, however, that as many Third World countries improve their bargaining power and the ability to absorb foreign technology, their quest for equity in contract negotiations with foreign multinational corporations has been growing. One of the consequences of this development is a growing interest in establishing joint ventures between multinational corporations and host Third World country governments or enterprises. According to Goulet (1989), "Pressured by new demands from governments, many TNCs which have favored direct foreign investments only when they could be sole owners of enterprises are now agreeing to become minority equity holders in joint ventures.

Joint Ventures

Joint ventures have become attractive as many MNCs seek to take advantage of similar benefits as in FDIs, but at the same time avoid the risk of nationalization that may be potentially high with FDIs. Broadly, a joint venture may be defined as "a partnership formed by a company in one country with a company in another country for the purpose of pursuing some mutually desirable business undertaking" (Certo, 1986, p. 521). In strategic alliances such as this, ownership is based on equity share. The partners in the alliance each provide a portion of the equity or the equivalent in physical plant, raw materials, cash, or other assets (Griffin, 1990). In some Third World countries, MNCs are limited in equity ownership to 50% or less. Even then, joint ventures are attractive to MNCs for reasons that are both tangible and intangible. First, the Third World private or government partner may contribute land and funding as well as vital knowledge of domestic markets, suppliers, and patterns of business practice (Kaynak, 1985). The alliance combines the technical expertise of the MNC with the understanding that the host-country partner has regarding how to circumvent or eliminate government red tape that may affect the operations of the firm. In addition, joint ventures offer a number of intangible advantages, such as creating goodwill with Third World governments, employees, and customers as well as reduced risk of nationalization or unfavorable government legislation (Kaynak, 1985). In a rather unusual alliance, Cabot Corporation, a major manufacturer of carbon black, agreed to "50% ownership in Malaysia and Iran, and in Brazil it sought an equity share lower than one-half so as to be legally able to charge technical fees to its Brazilian affiliate" (Goulet, 1989, p. 55). Still, other MNCs remain less tolerant of joint ventures that require substantial, not to mention controlling, interest held by host Third World partners. These corporations may prefer to have firms in the Third World manufacture or market their products under a licensing agreement.

Licensing Agreements

"Under a licensing agreement, a firm allows another company to use its brand name, trademark, technology, patent, copyrights, or other expertise" (Griffin, 1990, p. 794). The licensee in this case agrees to operate under specified conditions in addition to the payment of fees and royalties. The fees and royalties are usually based on a percentage of sales or value-added.

Licensing relationships can be between independent business enterprises, parent companies, and wholly or partially owned subsidiaries, and joint ventures between private and/or public firms. The dominant form of licensing occurs between MNCs and their affiliates in Third World countries. This is also the most suitable arrangement for transfer pricing. With improving absorptive capacity, an increasing number of Third World firms are signing licensing contracts with foreign MNCs as a technique to expand innovation domestically. According to Larson and Anderson (1994), “Licensing arrangements are generally associated with a greater degree of local, post transfer innovation as compared to other forms of transfer” (p. 548). As Third World countries gain in domestic technological capability, they are turning increasingly to licensing arrangements as a method of furthering domestic innovation. Japan, for example, made extensive use of licensing in its socioeconomic transformation into a world economic power. Where a country is interested in running a production facility after it is set up by a foreign source, the appropriate mode of transfer of choice may be a turnkey project.

Turnkey Projects

The last technology transfer technique is known as a turnkey project. A turnkey project is one in which a foreign organization undertakes the construction of a production facility and turns the key to a domestic firm or some other organization when the facility is ready for operation. “Investments funded by international organizations and government agencies are basically of the turnkey nature” (Stewart & Nihei, 1987, p. 11). Turnkey projects usually are more suited to a single activity production facility such as a cement factory, sugar refinery, steel mill, etc. For instance, several Indian steel mills were initiated through turnkey operations. A turnkey project may also include the training of domestic personnel to eventually take over the operation of the factory. It is worth noting that in a turnkey investment domestic personnel are able to operate the new plant but may lack the ability to set up a cement factory or a sugar refinery. The ability to reproduce or set up a production plant may indeed be more beneficial in terms of fostering self-sustaining development in the long run than having one from a turnkey arrangement in which the recipient only consumes or operates the technology involved.

Remaining Challenges

I have focused on explaining the concept of technology and the conditions in which it can be more beneficial to Third World countries in their efforts to achieve self-sustained socioeconomic development. Technology is a passive resource whose effectiveness depends on an active human resource capital. To take advantage of technology as a potent source of positive change, Third World countries must work hard on their absorptive capacity. It is erroneous to speak of technology transfer if the ability of Third World countries to assimilate, adapt, modify, and create technology is limited or nonexistent. Channels of technology transfer such as the MNCs will train Third World workers only to the extent it enables them to maximize profits. By their nature MNCs do not operate to make Third World countries self-sufficient, self-reliant, and able to do “their own thing.” Training domestic labor to be able to operate production facilities neither puts them in a position to produce capital goods nor automatically prepares them to be able to set up production facilities on their own. It is the ability to create and accumulate national capital, to set up the necessary infrastructure, and to operate and maintain the infrastructure that promotes self-sustained development.

The importance of producing domestic vocational education graduates, technicians, technologists, engineers, scientists, and entrepreneurs as sources of a country’s absorptive capacity cannot be stressed enough. Any country that hopes to develop a modern industrial system will realize sooner or later that developing this cadre of professionals is an indispensable requirement. Without these professionals in place to establish the foundational technical developments upon which the prosperity of a country depends, attempts to develop socially, economically, politically, and technologically will be no more than a false start. As experience has shown, this approach to development only serves to perpetuate Third World dependence on the West. It is perhaps appropriate to end with a quote that captures the message of this article: “A country’s comparative advantages increasingly lies [*sic*] in its ability to use effectively new technology, which is generally a function of the capacity of its population to absorb new technologies and incorporate them in the production process” (Aharoni, 1991, p. 80).

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Pupils Identify Key Aspects and Outcomes of a Technological Learning Environment

Yaron Doppelt and Moshe Barak

Over the past two decades, the contribution that a rich learning environment makes toward attaining educational goals such as improvement in learning achievements and attitudes towards studies and school has been considered in educational research (Fraser, Giddings, & McRobbie, 1995; Fraser & Tobin, 1991; Perkins, 1992). The term *rich learning environment* not only includes physical devices, such as experiment kits or computers, but also the teaching technique, the type of activity pupils engage in, and the method of assessment. Associating science and technology studies with a rich, flexible, computer-embedded learning environment may enable pupils to attain higher academic achievements and overcome their cognitive and affective difficulties (Barak, Waks, & Doppelt, 2000).

The Creative Thinking and Technology (CTT) program (Barak & Doppelt, 1998) was developed for that purpose. The CTT program's main goal is to cultivate creative thinking via project-based learning. The program integrates creative thinking tools from the CoRT 1 series of thinking tools (De Bono, 1986) within the technology curriculum (Barak & Doppelt, 1999). The pupils create authentic technological projects and prepare portfolios that are used for assessing the learning process. LEGO/Logo is attractive to technology education, as previous works have shown (Jarvela, 1995; Jarvinen, 1998; Kromholtz, 1998; Papert, 1991; Resnick & Ocko, 1991). The current research shows an application of LEGO/Logo by using pupils' authentic projects for learning technology as a major subject in high school. This article concentrates on the pupils' perspective on the preferred learning environment.

Background

One of the proclaimed goals of science and technology education is to enhance pupils' higher-order intellectual skills, such as mathematical-logical thinking and creativity (Gardner, 1993; Perkins, Jay, & Tishman, 1993; Sternberg, 1998). De Bono (1986) suggested a series of creative thinking tools that can be used as a general approach to teach thinking. Perkins and Swartz (1992) suggested that the fostering of thinking should be integrated in the learning of a specific context, such as science and technology.

Waks (1997) observed that lateral thinking initiates the learning process when working on a technological project, as pupils seek for alternatives and examine different solutions. Vertical thinking is essential in the stage of choosing a solution and developing it. Vertical thinking and lateral thinking complement each other, and both are the essential elements of creative thinking (De Bono, 1986).

Imparting creative thinking within science and technology education requires not only changing the teaching methods and learning environment, but also adopting new assessment methods such as portfolio assessment, which is based on records of pupils' activities. The portfolio can consist of written material, computer files, audio and video items, sketches, drawings, models, or pictures. The portfolio reflects what pupils have learned and how they question, analyze, synthesize, solve problems, and create new ideas or design and build useful products or systems. The portfolio also shows how pupils interact intellectually, emotionally, and socially with others (Collins, 1991; Wolf, 1989).

Perkins (1992) identified several features of learning environments: information database, symbol platforms, construction systems, phenomenarium (microworlds), and assignment organizers. A learning environment should be sufficiently flexible, allow different learning styles (Kolb, 1985), and develop different skills (Gardner, 1993; Sternberg, 1998). It should include a portfolio assessment of pupils' original projects, rather than pen and paper examinations.

A rich, flexible learning environment is necessary for accelerating the learning of at-risk pupils (Levin, 1992). How to advance low-achieving pupils is an on-going challenge for educational systems. Routing low-achievers to lower-level learning tracks creates a vicious circle. The school system has low expectations from the pupils, the pupils accumulate a history of failure, and the teachers emerge as having a low self-esteem and professional image (Barak, Yehiav, & Mendelson, 1994).

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The LEGO/Logo learning environment was selected as the basis for implementation of these guidelines. LEGO/Logo is a widely used learning environment for technology education in elementary and secondary schools. It combines LEGO bricks and Logo commands for creating procedures that control the prototype. In addition to the ordinary LEGO bricks, the LEGO systems contain motors, sensors, and gears that allow pupils to create complicated projects and to learn principles in technology and science. According to Resnick and Ocko (1991), the LEGO/Logo learning environment creates a community of learners, changes the teacher's role in class, and fosters the development of pupils' authentic projects as the basis for the learning process. Learning environments such as LEGO/Logo enable the learner to construct concepts (Papert, 1991). When pupils create an authentic project in the LEGO/Logo environment, they experience meaningful study that enables the exercise of sophisticated ideas that originate from their own projects.

The CTT program embraces the following: learning through completing authentic projects, integrating creative thinking activities into the technology curriculum, and allowing freedom to learn and encouraging learning from mistakes. Because the pupils study technology as a major, it is pertinent to create authentic technology projects as a way to advance pupils' competencies and knowledge. This article focuses on the influence of the CTT program upon affective and cognitive domains from the pupils' point of view.

Intervention

The CTT program (Barak & Doppelt, 1999) encompasses two hours of study each week during an entire school year. During the first semester (about 15 weeks), the class learns thinking tools from the CoRT 1 thinking program (De Bono, 1986). This program consists of a series of thinking tools, such as PMI (plus, minus, interesting), CAF (consider all factors), and APC (alternatives, possibilities, choices). In the first stages, the pupils learn and exercise these thinking tools by drawing examples from their daily lives. Later, learning focuses on design, construction, and improvement of small devices such as cars or robots using LEGO building blocks and mechanical components. For example, all pupils construct identical cars according to a given LEGO design, compare their features, and suggest improvements while using the CAF and APC thinking tools. In the course of this process, the pupils also become familiar with the LEGO/Logo system, the computer interface, and simple programming in *Multi-Techno-Logo*. This is a Hebrew version of LEGO/Logo that combines the advantages of Logo-Writer and LEGO/Logo using the mother tongue for programming (Doppelt & Armon, 1999).

During the second semester (about 15 weeks), the pupils choose and create original technological projects. As Barlex (1994) stated, "It is difficult to capture the breath of spring that successful technology project work brings to a wintry curriculum. Perhaps it's the risk of failure and the uncertainty with no right answers, only one possible solution" (p. 143). Barak and Doppelt (2000) reported that the pupils coped with complex problems and found solutions that were dependent on the synthesis of lateral and vertical thinking into creative thinking.

The pupils create portfolios in which they collect their documentation of creative thinking and other outcomes of the learning process. Over a period of several years, each class developed criteria for assessing the portfolios. A scale for assessing pupils' creative thinking through their portfolios was created on the basis of these experiences (Barak & Doppelt, 2000).

This scale comprises four levels: awareness of thinking, observation of thinking, thinking strategy, and reflection upon thinking. The proposed scale is applied to two portfolio domains: (a) learning outcomes, such as a piece of research, or a technological product, and (b) processes of learning, thinking, and teamwork in the class. Several examples of the scale's application to pupils' portfolios demonstrate how this methodological assessment can help educators to develop and evaluate learning assignments aimed at fostering creative thinking. Through designing, and systematically reflecting upon the portfolio, pupils can develop an awareness of their internal thinking processes and learn to direct their own thinking.

Research Goals

The main goal of this research was to learn

Pupil X assesses the influence of input A

INPUTS (15)

Learning styles	Class atmosphere
♦ Self learning	♦ Open mindedness
♦ Group discussions	♦ Acceptance of mistakes
♦ Team projects	♦ Tolerance of different opinions
♦ Individual progress rate	♦ Freedom to chose subjects
Pupil's activities	♦ Rich environment
♦ Thinking	Learning materials
♦ Designing	♦ Instruction sheets
♦ Programming	♦ Work sheets
♦ Construction	Other

on desirable pupil's outcome B

OUTCOMES (25)

Social integration	Desire to learn
Department pride	Critical thinking skills
Technical skills	Success in technology subjects
Mutual help	Interest in technology studies
Independence	Success in other subjects
Self-confidence	Interest in other subjects
Personal initiative	Desire to come to school gladly
Team work	Improvement in relationship with the teacher
Perseverance	Motivation to work at home
Self-responsibility	Increase in other pupils' appreciation of the department
Curiosity	
Imagination	
Challenge	

is

Very much
To
Very little

Figure 1. A mapping sentence for assessing "inputs" and "outcomes" of a technology project-based curriculum.
The pupils rate the contribution of each one of the inputs (for example, self-learning) to all the 25 outcomes. A sentence can have a structure such as, pupil 1 assesses that the influence of [self-learning] upon [curiosity] is [little].

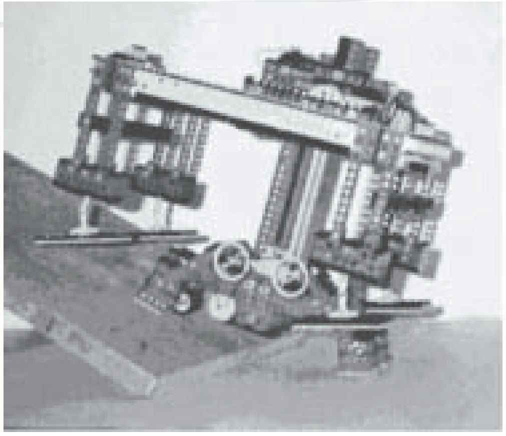
about pupils' perception of the influence the learning environment has on their outcomes. Several characteristics of learning environments have been expounded in the theory. This article focuses on the contribution of these characteristics to learning outcomes from the pupils' point of view.

Method

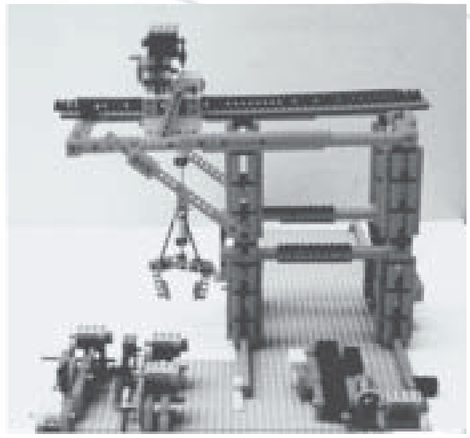
Subjects

The participants in this study were 10th grade pupils in a high school in northern Israel. These were low-achieving pupils who had chosen to major in the Machine Control Department. Some of the pupils chose this route on their own; others had been thus directed by school advisors, in whose opinion this route is the only solution for low achievers.

In Israel, at the end of junior high school, pupils have to choose one or more areas in which to major, such as sciences, humanities, art, or technology. The high school technology curriculum includes several major subjects that are related to physics and mathematics, such as computers and electronics, mechanics, and control systems. Typically, the "high achievers" are directed to computers and electronics and the "low achievers" are directed to mechanics.



a. An obstacle climbing robot



b. An object identifying crane

Figure 2. Examples of pupils' projects.

Barak, Yehiav, and Mendelson (1994) have previously raised the issue of integrating low achievers into technology studies in Israel. Some of the pupils considered here may fit Levin's (1992) definition of at-risk pupils.

The CTT program ran for five years between 1994 and 1998. A total of 56 pupils participated in this program (9 to 24 pupils each year). This article examines the program's influence on the first participating group of pupils, who were in 10th grade in 1994, through 12th grade in 1996.

Data Collection

This research combines qualitative and quantitative tools: observations of class activities, interviews with pupils and parents, and follow-up of the pupils' academic achievements. Such a combination has been found to be effective and contributes to the understanding of the research field (Fraser & Tobin, 1991). In quantitative research, it is common to validate conclusions from the findings of one instrument by the findings of another instrument (Denzen & Lincoln, 1994).

As a result of content analysis of the interviews, a questionnaire was developed for assessing pupils' progress in an open learning environment, in terms of the input-output relationship from the pupils' viewpoint. The mapping sentence presented in Figure 1 provides a flexible structure for researchers to construct and use similar questionnaires in classes (Waks, 1995). The terms for both the input and the output category were extracted from interviews with the pupils. This questionnaire is based on an assessment of the influence of a learning environment's inputs on pupils' outcomes. Pupils completed this questionnaire by rating each pair on a scale from 1 (*having a very high influence*) to 5 (*having a very low influence*).

Findings

Examples of Pupils' Projects

Over the five-year period during which the CTT program was implemented, 56 pupils built approximately 50 different team projects. All the ideas were suggested by the pupils themselves. Two examples are presented in Figure 2. Figure 2a illustrates a robot that moves forward or in circular motions and traverses obstacles, and Figure 2b depicts a crane that scans an area, collects randomly distributed objects, and then delivers them onto a train.

Other examples include an automatic conveyor belt that receives, identifies, and counts items loaded off a truck, and a chocolate drink machine that fills powder into a glass, mixes it with milk, and delivers the glass onto a conveyor. These examples demonstrate how the project-based learning approach enabled the pupils to create various authentic projects. These projects won nationwide attention from educational curriculum councils and other research groups.

Community of Learners

Observations in class revealed a variety of interactions between younger and older members of the Machine Control Department, between parents and children, and between pupils and teacher. An external spectator could observe pupils, who were working individually or in pairs, and the teacher, who circulated among the groups in turn. The laboratory became a second home to the pupils. They came to work on their projects during breaks and free hours, and even after school. They could familiarize themselves with projects made by former pupils who still visit the Machine Control Department from time to time.

Pupils' and Parents' Viewpoints

The following quotations, taken from interviews with pupils and their parents, demonstrate the impact of the CTT program and its influence on the learning atmosphere at school.

Adam: "It is very important to continue the LEGO/Logo lessons...it is a way for me to achieve my goal, in my way...there is freedom to choose, and nobody tells me what to do...the teacher only guides me...this is like independent learning...I like the creativity through the lessons. It gives the opportunity to understand the theoretical issues of mechanics."

David: "I was an average pupil in junior high school...since I came to the Machine Control Department I have changed...my achievements in the technology subjects are high...even in humanities subjects I have improved...the way we learn through LEGO/Logo, the team work, and the independence the teacher gives us all encourage us to help one another."

Benny: "We do not build robots only for fun, we learn how to design prototypes...we learn automation, center of gravity, it demands thinking, develops us, and we can apply what we learn...it is interesting and adds spice and motivation to learn more."

Mother of twins, speaking of her children who achieved well in the matriculation examinations and finished high school, despite both having a history of difficulties during junior high school:

> "There is a dramatic change in their self-confidence. They are alive and they have started to smile again; they were very sad in their past experiences in school. Learning LEGO/Logo has developed my son's thinking about how technology systems work. There was a drastic change in his self-confidence during learning in school."

A mother who decided to send her son to major in the same department as well as his sister:

> "I am proud that my daughter studies technology as a major. She started to learn from her own motivation...the LEGO/Logo strengthens her and it caused her to invest efforts in other subjects at school. It was a challenge for her...we are going to send her brother to the same department as well."

Questionnaire Results

A closed questionnaire was constructed in order to probe further the influence of the learning environment from the pupils' viewpoint, based upon the interviews with the pupils. The questionnaire included 15 "inputs" of the learning environment, such as freedom to choose subjects, team projects, individual progress, and construction activities. These aspects are considered as inputs of the learning environment because they are concerned with the organization of the learning in the class, such as various activities that have been introduced to the pupils, flexibility, and degree of freedom to choose activities. Pupils pointed to 25 outcomes that were influenced by the CTT program, for example, personal initiative, self-confidence, interest in technology studies, and challenge.

As mentioned above, the pupils rated the contribution of each input to each of the 25 outcomes on a scale of 1 (*very high*) to 5 (*very low*). An average score for each of the inputs and outcomes was calculated, representing the weight attributed by the pupils to the inputs and the outcomes. Figure 3 presents the final results, where the most significant inputs and outcomes are shown in rank order.

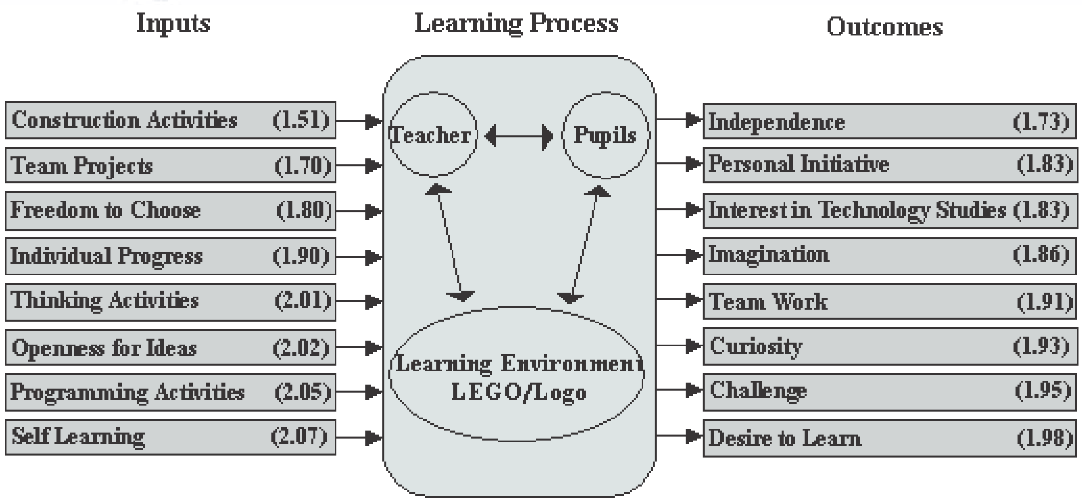


Figure 3. The most influential inputs upon the major outcomes of a rich technological learning environment from the pupils' point of view.

Discussion and Conclusions

The current research addresses the issues of how to promote low achievers by providing them with a rich, modern, and flexible technological learning environment. The pupils created authentic technological projects using their own imagination and documented their work in rich portfolios (Barak & Doppelt, 1999, 2000). Observations of pupils' activities in class, interviews with pupils and their parents, and questionnaire findings all indicated improved pupil self-esteem and self-confidence. Pupils changed their attitudes towards their everyday learning and their future intentions to continue studying.

The findings from this research suggest that educators invest resources in the development of learning environments that combine hands-on activities with what Papert (1980) has called "heads-in" activities. Computerized simulations and programming are important components in the learning environment, but they do not stand alone. Educators can use LEGO/Logo to advance learning and thinking. LEGO/Logo is attractive to technology education, as demonstrated in previous studies (Jarvela, 1995; Jarvinen, 1998; Kromholtz, 1998; Papert, 1991; Resnick & Ocko, 1991). Moreover, the current research shows an application of LEGO/Logo for studying technology, mainly mechanics and machine control, as a high school major.

The present study directs attention towards the kind of learning environments that pupils opt for: construction activities, team projects, and freedom to learn. The most important outcomes, in the pupils' eyes, are independence, personal initiative, and interest in technology. In many cases, the school ignores these outcomes because education systems concentrate mainly on academic achievements. A rich learning environment is especially important for low-achieving pupils. Sophisticated school science and technology labs are frequently reserved for the high achievers, while other pupils study craft in lieu of technology in outdated workshops, which are often located at the far end of the school.

Finally, the present findings regarding the most influential characteristics of the learning environment, from the pupils' perspective, agree with the principles that have guided the Accelerated Schools Project (Levin, 1992), aimed at advancing at-risk pupils. Schools should seek alternative ways to develop pupils' learning skills, instead of trying to offer them slow learning programs.

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Perspectives on Employing Individuals with Special Needs

James P. Greenan, Mingchang Wu, and Elizabeth L. Black

Since the Civil Rights Act of 1964 was implemented three decades ago, society has been engaged in improving the lives of people with disabilities (Sarkees & Scott, 1986). In 1977, the Secretary of Health, Education, and Welfare, Joseph A. Califano, approved regulations for Section 504 of the Rehabilitation Act of 1973 and said, "It will usher in a new era of equality for handicapped individuals in which unfair barriers to self-sufficiency and decent treatment will begin to fall before the force of the law" (Mancuso, 1990). Legislation such as Section 508 of the 1986 Amendments to the Rehabilitation Act of 1973, the Americans with Disabilities Act (ADA) in 1990 (Carney, 1990), the Individuals with Disabilities Education Act of 1990 and its 1997 amendments, and the School-to-Work Opportunities Act of 1994 were enacted to improve the lives of individuals with disabilities. This legislation was also enacted to facilitate the marketable and saleable skills of individuals with special needs and to facilitate their employment under the fewest limitations (Appell, 1990; Johnson & Halloran, 1997; National Center for Education Statistics, 1996; U.S. General Accounting Office, 1996).

In response to the requirements of the federal legislation and to increase the employment of individuals with special needs, vocational special needs educators have also been endeavoring to improve vocational programs by modifying teaching strategies and coordinating resources (Chadsey-Rusch & Gonzalez, 1988). In addition, computer technology is being applied to assist individuals with disabilities to learn and work. Further, supported employment is advocated for the employment of individuals with disabilities in the real world (Hill, Banks, Handrick, Wehman, Hill, & Shafer, 1987; Unger, 1999).

Employment accommodations do not necessarily guarantee employment success until a match is found between employee capabilities and the requirements of specific jobs (Bowman, 1987; Mancuso, 1990). Further, the employment rate among special needs populations does not increase directly in relation to the activities of vocational special educators and legislators (Bowe, 1990). Expenses related to accommodating populations with special needs are one of the major American economic costs. Social welfare subsidies for people who are either unemployed or not in the workforce comprise the majority of this expense. The subsidiary costs for special needs populations who were unemployed represent a large portion of these funds. The demographically changing workforce and the declining number of available workers has caused employers to pay more attention to the need for integrating persons with disabilities into the labor market.

The success of individuals with disabilities in employment is influenced by cooperation among employers and employees, support of legislation, and appropriate efforts of vocational programs (Greenan & Tucker, 1990; National Council on the Handicapped, 1987; Salomone & Paige, 1984; Storey & Garff, 1999; Tilson & Neubert, 1988). Therefore, transition services that are developed to integrate contributions from various resources and match supply-and-demand of business and industry in communities become the emphasis of the vocational special needs agenda (Sarkees & Scott, 1986).

Our Objectives

We sought to (a) enhance the awareness of employers' concerns related to the employment of people with special needs, (b) identify employers' difficulties encountered when attempting to assimilate people with disabilities in their businesses, (c) identify difficulties in applying computer technology to assist the employment of people with disabilities in their businesses, and (d) identify government policies that encourage employers to hire people with disabilities. This knowledge will potentially assist legislators and vocational educators to improve current policies. For people with disabilities, this knowledge is also crucial to meet their entry-level job-related skills requirements and plan their careers. In addition, the results can be important considerations for educators and computer companies for improving software to meet user needs in the world of work.

What We Did

The target population for this study consisted of all employers within industries and businesses in the state of Indiana. A list of local advisory committee members of secondary trade and industrial education programs composed of proprietors and vocational special educators (N = 1,200) was used. A random sample (n = 250) was selected for this study. This population was assumed to be representative of employers in Indiana.

A cross-sectional survey was developed to collect data regarding employer perspectives concerning the employment of individuals with disabilities. The questionnaire combined the researchers' experience, employers' suggestions, relevant literature, and instruments used in previous research. It was revised on the basis of the suggestions and recommendations of local leadership personnel in the fields of vocational education, special education, and rehabilitation, university faculty, and several employers in Indiana. The questionnaire was composed of 24 items and focused on four key areas: (a) employer awareness of current legislation related to the employment of individuals with disabilities and success of vocational special needs education programs, (b) employer perceptions on the employability of individuals with disabilities, (c) employer difficulties encountered while employing individuals with disabilities, and (d) employer expectations of government policies and relevant services that facilitate the employment of individuals with disabilities.

A 5-point Likert scale was used to identify employer attitudes. The responses were computed using the following scheme: *strongly disagree*, *disagree*, *uncertain*, *agree*, and *strongly agree*. After several revisions, the questionnaire was determined to have adequate content and face validity and internal consistency reliability. In addition, the Statistical Analysis Software (SAS) statistical packages were used to code, compute, and analyze the data for the study.

Each of the 250 subjects received a cover letter and a survey instrument. The letter and instrument described a wide variety of disabilities to assist the subjects in their responses. The disability categories included, but were not necessarily limited to, mild and moderate mental, physical, and learning disabilities, and visual and hearing impairments. Three weeks after the first mailing, the first follow-up letters and surveys were mailed to all nonrespondents. Second and third follow-up letters and surveys were mailed six and nine weeks after the initial mailing to all nonrespondents. After the final mailing, follow-up telephone contacts were made to all nonrespondents. The final response rate was 76% (n = 190), including usable and nonusable responses. To diminish the possible nonresponse bias caused by the low response rate, a method of resampling was used (Hartman, Fuqua, & Jenkins, 1986; Miller, & Smith, 1983). Resampling consisted of obtaining responses using telephone interviews from a sample (n = 10) of nonrespondents (N = 60). If item response results for the respondent and nonrespondent groups were not significantly different, it could be concluded that nonresponse bias did not exist.

The SAS packages were selected to generate descriptive statistics to answer the four research questions posited for this study. Both qualitative and quantitative methods were used to analyze the data. Open-ended responses were coded and analyzed for the four research questions using qualitative methods.

Resampling strategies using the telephone interview method were conducted to identify the reasons for nonresponses and the difference between opinions of respondents and those of nonrespondents. The comparison of results from respondents and those from resampled nonrespondents using an F test indicated that these two groups had similar awareness of the impact of the current legislation on employment of people with disabilities (F = 0.0, p = .99), information resources about vocational rehabilitation programs (F = .26, p = .61), and knowledge of assistive technology for people with disabilities (F = 1.08, p = .30). Since most of the resampled nonrespondents had no experience with people with disabilities, fewer than 5 of the 10 nonrespondents provided responses to research questions 2, 3, and 4. Quantitative data from fewer than five respondents are usually not considered statistically relevant. The F test indicated these two data sets were not significantly different. In addition, these two data sets yielded similar qualitative responses to the open-ended items.

All resampled nonrespondents stated that they had no experience working with people with disabilities. The major reasons for employers not hiring nontraditional employees were either their businesses were characteristic of intensive labor, such as driving and pushing trucks, or their businesses were too small to accommodate employees with disabilities. The majority of resampled nonrespondents also stated that they would be willing to employ qualified employees with disabilities if they applied. These responses were very similar to those of the respondents. It is, therefore, logical to conclude that the respondents' opinions could reasonably represent the opinions of the entire sample for the study.

What We Learned

Our findings are organized around the research questions that guided this study. They include:

1. ***To what extent are employers informed about the achievement of local vocational special education programs and current legislation with respect to the employment of individuals with disabilities?***

In regard to employers' awareness about the contribution of legislation and education on employment of people with disabilities, employers were somewhat aware of the impact of current legislation (e.g., the ADA) on people with disabilities (M = 3.75, SD = .83) and assistive technology for people with disabilities (M = 3.60, SD = 1.00), and they were also informed about the success of vocational rehabilitation programs for people with disabilities (M = 3.43, SD = 1.00). Although, there appears to be relative disagreement among respondents, employer awareness might indicate a concern with the employment of persons with special needs. The general public's intensive concerns with the current development of employment transition for individuals with disabilities are usually the main driving force for its implementation.

2. ***How satisfied are employers with the job-related performance of employees with disabilities?***

Employers demonstrated a willingness to hire qualified individuals with disabilities (M = 3.98, SD = .69). Employers generally believed employees with disabilities could perform as well as employees without disabilities (M = 3.48, SD = .96). Employers neither believed that employees with disabilities were unable to satisfy job requirements (M = 2.65, SD = 1.08) nor that they were unable to get along well with coworkers (M = 2.12, SD = .87). Employers also reported that their employees no longer worked for them because they sought other employment (M = 3.06, SD = .92).

In response to the open-ended questions, the reasons employees with disabilities were no longer employed included:

- We do not have experience in having employees with disabilities (25 responses).
- We have lost a few employees in the last eight years; if an employee with disabilities has left, his or her reason was not different than other employees without disabilities (1).
- They (employees with disabilities) sought a job they could do well (1).
- One gentleman got his workman's compensation settlement after his injury and quit to start his own business with the money (1).
- Employees with disabilities had personal problems that other people without disabilities have to some extent (1).
- Most employees were unable to get along with others (1).

Employers generally supported the employment of individuals with disabilities. They were also impressed with these persons' academic and interpersonal skills and favorable attitudes toward work. These perspectives are the fundamental and crucial components of successful employment transition for individuals with disabilities (Carney, 1990; Greenan & Tucker, 1990). The majority of surveyed employers stated that they did not have experience with employees with disabilities because none applied for jobs at their sites. The fact that most individuals with disabilities were not in the education pool also caused employers difficulty in hiring qualified disabled employees. Some employers indicated that employees could not get along well with coworkers. This finding implied that social distance existed to some extent between individuals with and without disabilities (Bowman, 1987). Rehabilitation counseling services are, therefore, urgently needed to optimize the congruence between individuals and their environments by counseling interventions such as expectation adaptation, behavior modification, and communication improvement (Szymanski, Hanley-Maxwell, & Asselin,1990). Further, employers needed some flexible administration strategies for supervising these nontraditional employees (National Council on the Handicapped, 1987). That is, employer services should be included in transition plans to assure effective transdisciplinary coordination among employment transition service delivery agencies (Szymanski et al., 1990).

3. *What difficulties do employers tend to encounter while employing individuals with disabilities?*

Employers possessed a variety of attitudes toward the job skills of people with disabilities (*M* = 3.03, *SD* = 1.00). In employing people with disabilities, employers did not believe these people have the following difficulties: inadequate academic skills (*M* = 2.61, *SD* = .86), negative attitudes toward work (*M* = 2.32, *SD* = .74), and lack of interpersonal relationship skills (*M* = 2.57, *SD* = .74). Employers reported that they were slightly aware of information resources of peripheral and assistive devices (*M* = 2.86, *SD* = .93). Also, employers believed that assistive devices were applicable to their businesses (*M* = 2.71, *SD* = .91). Their opinions on the affordability of assistive devices varied (*M* = 3.14, *SD* = 1.02). Small businesses generally reported that this type of assistive equipment was too expensive.

The open-ended responses indicated that:

- We are willing to take a chance when a good match of a student's needs and training site is found.
- Abilities to think and act quickly are needed for most of our jobs, but then most employees without disabilities have the same problems.
- No individual with disabilities has applied for a position to date.
- Few applicants with disabilities in the education pool have disabilities.
- I do not think they (individuals with disabilities) can apply to my business (an engineering lab setting, a woodworking lab, railcar maintenance industries, or other labor intensive businesses).
- In industries, only a skilled and semiskilled workforce is needed. No job is available for them (employees with disabilities).
- To date, there is no training required by state law. There is an inability to make adaptations.

Regarding difficulties in providing peripheral and assistive devices to employees with disabilities in employment, employers generally possessed uncertain and a variety of attitudes toward accessibility to relevant resources and the affordability of equipment. However, employers generally believed that assistive technology would be available to their businesses in order to enhance the employment of people with disabilities. In spite of some employers' statements that no problems existed with employees with disabilities, the open-ended responses indicated some reluctance toward applying assistive technology in the employment of people with disabilities:

- It (applying advanced technology to employment of people with disabilities) has not become important.
- We do not have experience in this area.
- We do not have adequate information regarding this type of assistive technology.
- Cost is difficult for a small business.

Employers participating in this study generally believed that individuals with disabilities possessed the fundamental job requirements such as general job skills, academic skills, attitudes toward work, and interpersonal skills. However, the high unemployment rate of these competent individuals could result from either their lack of specific skills for certain jobs or their lack of motivation to seek and obtain employment. Employers speculated that education systems could provide more specific job skills and counseling services to individuals with disabilities and help them initiate careers from available job positions. It may be due to the employers' limited understanding, special needs populations' lack of job skills, or poor communication between employers and individuals with disabilities. Some employers believed that people with disabilities could not work in labor-intensive job settings. Employers realized the feasibility of assistive technology for the employment of individuals with disabilities and recognized the availability of information resources. However, unacceptable high costs were believed to be the main obstacle for purchasing this type of equipment. This finding was contradicted by employers who had utilized assistive devices and found that the costs of remodeling and purchasing assistive equipment for disabled employees were close to that for employees without disabilities (National Council on the Handicapped, 1987).

The beliefs of employers concerning the high costs of assistive devices might reflect that inadequate information has been provided by rehabilitation agencies and assistive technology manufacturing companies. Several governmental funding programs and assistive device manufacturing companies have been established to financially assist industry and business in purchasing assistive devices (Reeb, 1989; Webb, 1992). However, these policies seemed not to be known and benefit potential consumers. Dissemination plans regarding the availability and utility of these resources should be known for the development and utilization of advanced technology.

4. What support services do employers tend to need to successfully employ people with disabilities in their businesses?

In order to support the employment of people with disabilities, employers were willing to provide employment opportunities (*M* = 3.77, *SD* = .63), job training (*M* = 3.38, *SD* = .86), and promotion of job redesign (*M* = 3.31, *SD* = .85). Respondents demonstrated various interests in providing monetary contributions such as financial contributions (*M* = 2.80, *SD* = .91) and tools and/or equipment used in their business (*M* = 3.01, *SD* = .83) to vocational programs.

The incentive factor that would most effectively encourage the employment of individuals with disabilities was public support (e.g., equipment subsidies, funding, staff, and employee training; *M* = 3.62, *SD* = .91), followed by tax benefits (*M* = 3.51, *SD* = .96), access to a community resource network (*M* = 3.51, *SD* = .82), and public relations (*M* = 3.36, *SD* = .92).

Regarding the factors encouraging employers to hire people with disabilities, employers responded that:

- Proper training and skills are only needed; no outside help is needed.
- Employers have no problem with hiring people with disabilities when they are able to perform needed jobs and jobs are available at the same time.
- Getting the government out of the private business sector makes it easier to terminate employees.

Since employers were willing to provide job training and employment opportunities to individuals with disabilities, it could explain their concerns with special needs populations and their realization of the importance of employment for people with disabilities. This assumption also indicates that employers believed that only specific job skills for certain positions were needed in industry and business. Employers were generally hesitant to provide monetary contributions to local vocational rehabilitation programs. This might imply that employers were not sure how contributions would be used. That is, employers might be unaware of the successes and activities of local vocational rehabilitation programs.

However, monetary incentives such as tax benefits and public supports were higher priorities than others. Employers believed that accessibility to a community resource network would effectively encourage them to hire employees with disabilities because of the importance of information resources. Employers desired financial aids to purchase assistive devices and remodel facilities for nontraditional employees, and they needed staff and employer training programs to improve their administrative strategies for supervising employees with whom they were not familiar. Some government regulations regarding the employment of individuals with disabilities were viewed as inappropriate, even harmful, to industry and business. This response demonstrated that either employment transition plans needed further communication among legislative agencies and communities or the appropriateness and effectiveness of government regulations should be reevaluated. Disability professionals, therefore, play a crucial role in bridging the gap between employers and individuals with disabilities and facilitating the interdisciplinary collaboration for the success of employment transition for individuals with disabilities (Szymanski et al., 1990).

When asked to make additional comments, suggestions, and recommendations regarding the employment of individuals with disabilities, individual employers responded that:

- The only comment I would have is the degree of disability and the equation between production and wages.
- I believe people with disabilities are capable of doing a very good job in certain positions, however, our business is

very labor intensive and I am not sure in this case. It would depend on the particular disability.

- I have employed a disabled employee. He was capable in electrical construction activities. Safety is primary. A prospective employee must be capable of performing construction activities without jeopardizing his or her own safety or the safety of his or her teammate.
- If they know how and are able to perform, I will hire them just like anyone else.
- We run only a small business and do not have funds to renovate our whole facility to accommodate physically handicapped persons. However, we are willing to work with the mentally impaired.
- The labor pool, handicapped or not, is basically unskilled. We need more semiskilled and skilled workers. The biggest threat to our business and the creation and retention of jobs is government regulation.
- We have hired one person in the last 6–7 years. If a person can handle a job and has a disability, no problem. We are too small and too poor to provide special training. We cannot afford to go far enough on health insurance for those we employ.
- The one person employed who has a disability, left leg crippled by polio, I found that he thinks the world owes him a living.
- Besides employment opportunities, we utilize a rehabilitation center whenever possible for cleaning and simple manufacturing services.
- I would like to see improvements in job training on electronic motor repair, wheel pump repair, and office jobs.
- Better public relations are needed. It is too expensive for employers to accommodate them. Who is going to pay for the remodeling of facilities?
- I am appalled that the Congress and some branches of the federal government have been excluded.
- Our people must do shampoos, styles, cuts, fingernails. These jobs may be difficult for a disabled person to perform.
- Our business has no need for extra employees. Farming involves use of heavy machinery and chemicals under sometimes adverse conditions. There would be no place here for most handicapped people and use of them could develop life-threatening situations. Liability would be too great.

Most employers obviously held favorable attitudes toward individuals with disabilities and were willing to hire them if their job skills matched available positions. Applicants' specific job skills, interpersonal relationship skills, motivation to search for employment, and knowledge about safety were the major considerations in employment practice. To the proprietors of small businesses, individuals with disabilities were generally perceived to be unqualified due to their lack of versatility in several different types of job positions. The financial investment in remodeling facilities and purchasing assistive devices for employees with disabilities were major difficulties in hiring them. However, the existing financial aid programs seemed not to benefit them due to limited marketing plans or inappropriate strategies. From the employers' point of view, government incentive policies could facilitate employment transition for individuals with disabilities; whereas, mandatory regulations would only prevent employers from hiring these nontraditional employees. In order to overcome the barriers existing in the employment of nontraditional employees, industry and business need disability professionals to provide strategies for supervising and communicating with employees with disabilities. They also expected government to provide appropriate job training to individuals with disabilities before requiring them to hire these nontraditional employees. Therefore, further communication and professional coordination among resources in employment transition were the highest needs at this time.

Implications and Importance

Contributions from a variety of resources, such as legislation, vocational special education, assistive technology manufacturing companies, and individuals with disabilities, have created a remarkable impact on the employment preparation of individuals with disabilities. However, the current low employment rate of special needs populations seems to result from poor transition planning, lack of program coordination, and insufficient information resources (Szymanski et al., 1990). This study was conducted to further understand the existing obstacles and possible resolutions to the improvement of employment of individuals with disabilities. The foci of this study included employers' awareness of current legislation regarding employment of special needs populations and the activities of vocational rehabilitation programs, employers' difficulties and expected incentives when they try to hire nontraditional employees, and the availability of applying assistive technology to their businesses for special needs employees.

As with most studies, this study had some limitations. The sample used was randomly selected from local advisory committee members of secondary trade and industrial education programs in the state of Indiana. However, these employers did not likely represent all employers in the state of Indiana. It was assumed that employers would be entirely frank to express their perspectives on the posited questions, but some employers might have tried to avoid the suspicion of discrimination and concealed their negative attitudes toward some issues. The other limitation could be caused by the low response rate. Only 41.04% of the sample completed the survey questionnaires. In order to minimize the possible nonresponse bias, a telephone follow-up survey of nonrespondents was utilized to identify the reasons for nonresponse and the differences between perspectives of norrespondents and respondents. The telephone follow-up survey revealed that nonrespondents possessed perspectives similar to the respondents. Therefore, only low response bias may exist.

Several conclusions may be drawn from this study. First, employers were generally concerned with the employment of individuals with disabilities and relevant issues regarding people with disabilities. Second, employers were impressed with these persons' high potential to work in terms of academic skills, interpersonal skills, and positive attitudes toward work. Third, employers also realized the function of assistive technology used for the employment of individuals with disabilities and the importance of employment for individuals with disabilities and communities. They were willing to provide employment opportunities and relevant contributions to them whenever applicants' job skills matched certain positions.

The favorable perspectives of employers provided an advantageous environment for the employment transition of individuals with disabilities. However, the existence of the low employment rate of individuals with disabilities implied that several challenges still existed in some aspects such as counseling services, vocational programs for special needs populations, government policies, and the development and utilization of assistive technology and included the following: Limited communication among employment transition agencies inhibited individuals with disabilities from entering and succeeding in employment; employers perceived that vocational rehabilitation programs failed to prepare individuals with disabilities with the specific job skills needed in the world of work; some government regulations were believed to be inappropriate, even harmful, to the employment of individuals with disabilities; and employers realized the applicability of assistive technologies but did not benefit from it due to limited accessibility to information resources and financial aids.

Successful employment transition of nontraditional employees needs more professional coordination and transdisciplinary collaboration than individual service delivery systems (Szymanski et al., 1990). Accordingly, the following recommendations are offered:

1. Further communication and collaboration among a variety of agencies and resources should be facilitated by counseling services that are important to the employment transition for people with disabilities.
2. Vocational programs for special needs populations should consider the recommendations of business and industry along with student needs to better prepare students for employment.
3. Teachers in special needs education are the first counselors and facilitators. They should develop and implement appropriate curriculum and instruction for students with disabilities to improve their job-related skills and motivation for work.
4. Some government regulations related to the employment of persons with disabilities should be reevaluated and adjusted to match employer considerations and needs.
5. Professional coordination is necessary to satisfy the assistive equipment needs and interdisciplinary collaboration of

individuals with disabilities.

6. Disability professionals at the university level should provide industry and business with professional training concerning strategies for supervising employees with disabilities to assist employers to manage issues accompanied with nontraditional employees.
7. Future studies should include more diverse samples and populations to examine the issues from a greater variety of employers.
8. Further studies should consider adopting naturalistic methods of inquiry, such as case study, to gain a more in-depth understanding of the issues under examination.

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Technology Education in New Zealand

Michael Forret, Alister Jones, and Judy Moreland

Technology is one of the seven essential learning areas included to achieve the knowledge and understanding that all New Zealanders need to acquire (Ministry of Education, 1993). Responsibility for the implementation of these curricula rests with schools which have flexibility in making implementation decisions. Within the national curriculum framework, all curriculum statements must reflect the principles of the national curriculum framework, specify clear learning outcomes against which students' achievements can be assessed, have learning outcomes or objectives defined over eight progressive levels, and be grouped in a number of strands. The national curriculum framework's principles relate to learning and achievement, development of school programs, and aspects of social justice and equity.

The Technology Curriculum

The general aim of *Technology in the New Zealand Curriculum* (Ministry of Education, 1995) is to achieve technological literacy for all New Zealanders. Technological literacy is seen as an amalgam of three strands aimed at developing technological knowledge and understanding, technological capability, and an understanding and awareness of the relationship between technology and society. Each of these strands is seen as equally important, to be taught as an integral whole rather than as separate parts. This integration recognizes that technology has its own knowledge base, involves practical and procedural skills and techniques, and cannot be separated from the social and cultural environment within which it takes place. Technological activities in the classroom are intended to be based on learners identifying needs and/or opportunities that can be addressed through technological design and problem solving and on learners developing the knowledge, skills, and social awareness necessary to understand and critique modern technological practice.

The practice of technology covers a diverse range of activities. Each technological area has its own technological knowledge and ways of undertaking technological activity, and it was considered important that students experience a range of technological areas and contexts. Learning in a variety of technological areas and contexts is thought to develop more effective understanding of technological principles as well as enhance the transfer of knowledge between contexts and areas (Jones, 1997; Perkins & Salomon, 1989). Allied to developing a broadly based curriculum was the desire to have the curriculum reflect technologies that were appropriate in the New Zealand context (Jones & Carr, 1993). It was therefore decided to include the following technological areas: materials technology, information and communication technology, electronics and control technology, biotechnology, structures and mechanisms, process and production technology, and food technology.

The technology curriculum also recognizes the centrality of graphics and design in all technological areas, and rather than listing graphics and design as a separate technological area, it is expected to be an integral part of teaching and learning in all areas of technology education.

In 1999 technology became a compulsory part of the school curriculum for years 1–10. It is optional in years 11–13 (senior secondary school). It was therefore necessary to develop strategies to support teachers in the implementation of this new curriculum area, and the Centre for Science and Technology Education Research, University of Waikato, has been closely involved in a number of research and development projects to enhance the teaching and learning of technology. These projects include teacher professional development, resource development in association with Technology Education New Zealand and The Royal Society, and classroom research.

Teacher Professional Development

Teachers' understanding and perceptions of a subject have a considerable impact on their interpretation and subsequent implementation of that curriculum (Goodson, 1985). Because most New Zealand teachers currently have little or no background in either technology or technology education, their perceptions tend to be narrow, seeing technology as essentially concerned with modern, sophisticated machinery and electronics (Jones & Carr, 1992). While teachers' views of teaching are much more informed, they are subjective, having been developed within the subject subculture with which they identify (Paechter, 1992). For the introduction of technology this was a multiple problem. Not only were teachers' views of technology inconsistent with the much broader view of technology inherent in the technology curriculum statement, but their approach to teaching technology was likely to be dominated by their subject subculture's consensus view of the nature of the subject, the way it should be taught, the role of the teacher, and what might be expected of the student (Paechter, 1992).

There was a danger that approaches to teaching technology would be based on techniques more suited to other subjects and that these approaches would be applied to a distorted version of the curriculum. Consequently, teacher development programs were developed to enhance teachers' understanding of technology and technology teaching (Compton & Jones, 1998). In these programs it was seen as important to develop not only a broader concept of technology, but also awareness and understanding of technological practice. The implications of this were that teachers needed to experience technological practice in some form to become confident in the teaching of technology. Learning about technological practice was not sufficient. It needed to be experienced, reflected on, and critically analyzed in terms of a concept of technology that was compatible with the curriculum statement (Jones & Compton, 1998).

Two programs were developed and trialed in the New Zealand context: the National Facilitator Training Program and the Technology Teacher Development Resource Package Program.

National Facilitator Training Program

The Facilitator Training Program was a year-long program and ran for two years, 1995 and 1996. It involved training a total of 30 educators—15 each year—from all over New Zealand. Program evaluations by the participants (facilitators) indicated the importance of developing a theoretical perspective of technology education. This was found to be particularly helpful when discussing implementation issues with school managers and boards. Participants also stressed the importance of learning about the techniques and practices of different technological areas.

Following the training program these facilitators worked with teachers on a national basis. Teachers' evaluations of these programs were very positive, with 87.2% of responses rating the program as above average or excellent. The majority of teachers commented that the program had met their needs and requested further teacher development of this kind. Most of the teachers (83%) found that the programs developed by the facilitators had helped them with their understanding of technology teaching generally and the technology curriculum specifically. Over half of the teachers (63%) also found the program helped them with their understanding of the concept of technology itself. Approximately three quarters of the teachers (76%) considered the areas of school and classroom implementation had been helpful, and over half of the teachers (66%) had found the program helpful in providing them with ideas for classroom activities—even though this was not a primary focus of the programs.

National Technology Teacher Development Resource Package Program

The Technology Teacher Development Resource Package Program was trialed in 14 schools over a three to six month period in 1996 and included video material of technological practice, classroom practice, and accompanying explanatory text as well as workshop activities. All the evaluations both in the trial schools and from subsequent general use indicate the successful nature of these programs and the usefulness of the model as a basis for teacher professional development in technology education. This resource package (Ministry of Education, 1997) is now used in most schools and forms the basis of nationally funded professional development in New Zealand.

Key Features of Teacher Professional Development

Our experience with these teacher professional development programs, designed to be consistent with both New Zealand's national curriculum statement in technology and relevant research findings, suggests that the following features are central in their success. In these programs it was important to develop:

- robust concepts of technology and technology teaching;
- understanding of technological practice in a variety of contexts;
- technological knowledge in a number of technological areas;
- technological skills in a number of technological areas;
- understanding of the way in which people's past experiences both within and outside education impact their conceptualization of technology teaching; and
- understanding of the way in which technology content and experiences can become a part of the school and classroom curriculum. This must be based on a sound pedagogy in keeping with the concept of technology education.

Developing Resource Material Which Emphasizes Effective School/Enterprise Links

The curriculum document for technology emphasizes that the link between schools and the community, including business and industry, tertiary institutions, and local authorities, is important to a well-developed, inclusive technology curriculum. It is expected that students will develop an understanding of the nature of technological practice and recognize its similarities and differences between different communities of practice. A successful resource assisting teachers in this area is the Delta Series (The Royal Society of New Zealand, 1999). This is a collaborative venture between TENZ (Technology Education New Zealand), IPENZ (Institute of Professional Engineers of New Zealand), and The Royal Society of New Zealand.

The Delta Series consists of a series of case studies built around school enterprise links. For example, five of the units have involved links specifically established through the IPENZ Neighborhood Engineers program. Each case study incorporates reflective comments from teachers involved. The outside experts associated with the technological activity have also commented on the knowledge and experience they were able to bring to the process. An additional feature is an external perspective provided through comments offered by a reference panel of experienced technology educationalists, including researchers.

It is hoped that the case studies will be used constructively both by classroom teachers and those from the wider community who are interested in becoming involved in technology education programs in schools. Those teachers who are just starting the process of developing their classroom technology programs will gain an insight into the thinking of others who have taken positive first steps along the path. More experienced teachers will be able to reflect on the experiences and views of others as they work to refine their own programs to better meet the needs of their students and local community. The wider community should be able to see ways in which they too may be able to become involved at all levels of the technology curriculum.

Enhancing and Sustaining Classroom Practice Through Research and Development

There are two research programs (Moreland & Jones, 2000; Moreland, Jones, & Northover, 2001) that have been examining classroom practice in technology, particularly in the area of formative assessment. The first examined existing practice, while the second explored the development of effective formative interactions. This research feeds directly into a resource development strategy for use by classroom teachers.

Research Methodology

The first year of the research (1998) explored teachers' emerging assessment practices in teaching technology. Nine teachers (two male, seven female) from two primary (years 1–6) schools were involved. The teachers' classroom experience ranged from a first-year teacher to a teacher with 16 years of experience. In terms of technology teacher development, three had had minimal involvement; two, moderate involvement; and four, extensive involvement over a whole year.

The research focused particularly on teachers' concepts of technology and classroom practices in technology. A case study approach was utilized to gain an understanding of classroom assessment practices in technology. The project was set within the theoretical framework that technological knowledge and assessment knowledge is socially constructed and context dependent.

The researcher took the role of a participant observer in the classroom during the technology education sessions; this contact involved 100 hours. Several methods of data collection were used including classroom observations, field notes, individual and group interviews, and written responses. Throughout the process, individual and group interviews provided an opportunity to explore student interaction with the classroom activities. Group interviews were valuable since many of the students worked collaboratively and the research endeavored to take this into account. Teachers' observations and comments provided further consideration of context and student performance.

The classroom discussions between the teacher and students and the students themselves were taped and analyzed. Students' written work and teachers' written material, including planning and assessment, were collected and analyzed. All of the analyzed data were then used to write individual case studies for each of the nine teachers involved in the research. The case studies are presented in *Case Studies of Classroom Practice in Technology* (Moreland & Jones, 1999).

The second year of the research was expanded to involve working in five primary schools (years 1–8) with 14 teachers (3 male, 11 female). The teachers' classroom experience ranged from a second-year teacher to a teacher with 26 years of experience, while technology teacher development ranged from minimal involvement to extensive experience, such as a technology facilitator.

Contact during this year included classroom observations, individual and group interviews, and teacher observation and comment. Workshops were an essential part of the process of enhancing assessment procedures, with the teachers attending seven days of workshops: an initial three-day workshop and two, two-day workshops spread through the year. The first three-day workshop focused on discussions of the findings from the 1998 research and the implications. As well, the models for assessment developed by the research team were introduced and trailing began. The second two-day workshop offered the teachers opportunities for reflection and enhancement of the use of the models. The final two-day workshop focused on assessing the use of the models and their further enhancement.

Year One Research Findings (Existing Practice)

After substantial classroom research in 1998, there appeared to be significant problems for teachers in assessing technology. Teachers commented that their difficulties were not just confined to technology but were also related to other subjects. In comparison with earlier research (Jones & Carr, 1992) it was found that, as a result of the teacher development models discussed earlier and the trialing of curriculum material in classrooms, teachers had developed broader concepts of technology (Jones & Compton, 1998; Moreland, 1998). These concepts, however, were still not broad or detailed enough to take into account many conceptual and procedural aspects, and this appeared to be confining teachers' assessment in technology to assessing affective aspects of learning such as enjoyment and the social and managerial aspects such as working in groups, turn-taking, and sharing. Technology had yet to become an integral part of the talk of classroom teachers and the community. This meant that a shared language of technology had not developed to any degree of specificity, which Black (1998) stated is vital for assessment.

In their planning of technology, teachers were focusing on the activities rather than on specific learning outcomes. With this focus on activities it became almost impossible for teachers to provide feedback at the conceptual and procedural level. The learning outcomes that were identified were often not technological and therefore learning in technology was not enhanced.

Formative assessment was not well understood in technology. Like the learner, the teacher needs to have a perception of a gap between a desired goal and where the student is currently operating. They also need to know what action needs to be taken to close the gap in order to reach the desired goal (Black & Wiliam, 1998). These teachers were not able to articulate what that gap might be in terms of conceptual and procedural aspects because they did not know what the desired goal was. They therefore could not know what detailed action to take because they did not know where the student was going, or even the current position of the student.

Also impacting teacher assessment practices in technology were the existing subcultures in schools. What teachers relied on for assessing in technology became largely dependent on what they already did and knew in other curriculum areas. All teachers in primary schools have common understandings of teamwork, leadership, turn-taking, discussing, depicting ideas, gathering information, describing, reflecting, etc., and these common understandings of social and managerial skills had became the focus of assessment in technology.

Year Two—Developing Formative Interactions

During this year, the conceptual and procedural aspects of learning in technology were highlighted as the means to enhance teachers' formative interactions and the learning outcomes for the students. This resulted in teachers moving from using general concepts about technology to more specific concepts within different technological areas. For the first time teachers were able to identify the specific technological learning outcomes they wished to teach and assess. The teachers' developing conceptual and procedural knowledge enabled them to write specific learning outcomes, and they began to move with more confidence between the generic dimensions of the nature of technology and the specific technological learning outcomes associated with particular technological areas.

This shift in focus from providing a technology experience to providing opportunities for students to develop technological learning outcomes was significant. They became focused on the technological learning of their students. Teacher talk about technology education had a higher profile and was increasingly embedded in teacher conversations. Teacher talk also developed relating to progression and the linking of learning outcomes from one unit to the next as illustrated by this teacher's comments:

> I felt we were looking for progression and I felt that the children built on certain things that were covered last time very well. There was a lot more movement in the iterative process this time. The children really started to move backwards and forwards through the design process very well… we might go on to extend by looking at different types of food packaging…going perhaps to the opening mechanism of packages as well…so we can start looking at the ergonomics of packages …we could go more into specification drawings or perhaps three dimensional conceptual drawings.

Teachers demonstrated greater confidence with formative assessment, particularly in relation to providing appropriate feedback to the learners. Not only was there more emphasis on providing feedback and assistance to students to develop particular technical skills, there was also more emphasis on conceptual and procedural aspects rather than social and managerial aspects. Additionally, there was less emphasis on praise as the sole formative interaction and more emphasis on assisting students to move on, to reflect, to assess their own progress.

The models that were developed in the project had a key role in enhancing the teachers' planning and classroom strategies. The teachers valued the following intervention strategies:

- Identifying specific and overall learning outcomes rather than just activities.
- Identifying procedural, conceptual, societal, and technical learning outcomes.
- Summative assessment during the unit as well as at the end.
- Questioning using technological vocabulary.
- Allowing for multiple outcomes.

These are illustrated in some of the teachers' comments below:

> Dividing planning into conceptual, procedural, societal, and technical allowed me to more effectively hone in on the technology involved.

> The identification of possible and planned learning outcomes made me more aware of the questioning that would be required.

Evident was the development of initial teacher understanding of progression in student learning in technology. This was reflected in task selection and development. Tasks were identified to develop particular conceptual and procedural aspects rather than just providing a variety of experiences. The use of the models also enabled the teachers to differentiate between the different levels of effectiveness of student learning and to explain the differences. The teachers also noticed enhanced student learning. Their comments were illustrative of this:

> Children's differences in learning can be better identified with specific learning outcomes with more effective children coping with more variables.

> Have had quality opportunities to show what they can do with improved vocabulary, language, and skills.

> The more effective children were engaged all of the time; they had the vocabulary and could use it appropriately. This was evidenced in their mock up and drawing.

The teaching, learning, and assessment strategies that have been developed in this intervention year also impacted the teaching and learning in other curriculum areas. All teachers made comments on this, for example:

> I am looking at making my learning outcomes very focused for other curriculum areas to develop more purposeful and structured formative and summative assessment practices. I am thinking more carefully about what I want the children to learn.

> I am now probing, in-depth questioning and constantly challenging. I am thinking about how my learning activities link and how I can help children transfer ideas and skills.

This research project has developed intervention strategies that encourage teachers to identify the conceptual, procedural, societal, and technical aspects, task definition, and aspects of holistic assessment. The results are very encouraging with the focus at the conceptual and procedural level rather than in terms of an activity.

General comments made by the teachers at the conclusion of the year included the following:

> My technology teaching has made huge leaps forward because of my involvement. It has been very demanding, but the risks have been worthwhile.

> The models have helped immensely, and it has been particularly rewarding to see the quality of work that is being produced by the children as a result of the research.

Continuing the Process

To successfully introduce and sustain a new curriculum requires a long-term research and development program that informs classroom practice. In New Zealand, this program has included teacher development, resource development (for teacher development and classroom materials), development of strategies to enhance teacher knowledge and classroom practice, and mechanisms for the dissemination of the research findings to inform all teachers.

Our research has shown that to improve and sustain learning in technology, it is necessary to enhance both teachers' technological knowledge and their understanding of technological practice. Resources and teacher development programs based on these goals have proved very successful in improving teachers' confidence and competence in teaching technology.

While teacher development programs helped to improve teachers' understanding of technology, classroom research has shown that teachers required further help with assessing technology. In particular, teachers found it difficult to identify specific conceptual and procedural aspects of technological learning, relying instead on social and managerial outcomes to define their desired learning. To assist teachers with this problem, well-developed models were used to focus the teachers' attention on the conceptual, procedural, societal, and technical aspects of student learning in technology. These models have allowed teachers to identify their knowledge gaps in technology and encouraged them to develop effective strategies to address these gaps and become more effective in the classroom. As highlighted by Fenstermacher (1994), it is more important that teachers know what they know than for researchers to know what teachers know.

However, while these results are encouraging, this is only the beginning, and more research and development work is required to develop sustained classroom practice in technology consistent with the New Zealand technology curriculum.

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Recognizing Surface Roughness to Enhance Milling Operations

Mandara D. Savage and Joseph C. Chen

Metal cutting is one of the most significant manufacturing processes in the area of material removal (Chen & Smith, 1997). Black (1979) defined metal cutting as the removal of metal chips from a workpiece in order to obtain a finished product with desired attributes of size, shape, and surface roughness. Drilling, sawing, turning, and milling are some of the processes used to remove material to produce specific, high-quality products.

The quality of machined components is evaluated by how closely they adhere to set product specifications of length, width, diameter, surface finish, and reflective properties. In high-speed turning operations, dimensional accuracy, tool wear, and quality of surface finish are three factors that manufacturers must be able to control (Lahidji, 1997). Among various process conditions, surface finish is central to determining the quality of a workpiece (Coker & Shin, 1996). Attaining and tracking a desired surface roughness is more difficult than producing physical dimensions because relatively more factors affect surface roughness. Some of these factors can be controlled and some cannot. Controllable process parameters include feed, cutting speed, tool geometry, and tool setup. Factors that cannot be controlled as easily include tool, workpiece, and machine vibration; tool wear and degradation; and workpiece and tool material variability (Coker & Shin, 1996).

Techniques of Surface Roughness Measurement

Surface measurement techniques are grouped into contact and noncontact methods. An amplified stylus profilometer is the most popular and prevalent contact instrument used to measure surface roughness in industry and research laboratories because it is fast, repeatable, easy to interpret, and relatively inexpensive (Mitsui, 1986; Shin, Oh, & Coker, 1995). In addition, stylus profilometers are used as the standard for comparing most of the newly invented surface roughness measurement instruments or techniques. This instrument uses a tracer or pickup incorporating a diamond stylus and a transducer. Running the stylus tip across the workpiece surface generates electrical signals corresponding to surface roughness. The electrical signals are amplified, converted from analog to digital, processed according to an algorithm, and displayed. The measurement has a fairly good resolution and a large range that satisfies the measurements of most manufactured surfaces. However, this stylus profilometer is limited because it requires an excessive amount of time to scan large areas, it has a limited range of use on nonflat surfaces, and it is restricted to off-line use (Shin et al., 1995). Off-line and in-process measurements are compared in the next section.

In-Process Versus Off-Line Measurement

Monitoring can be performed in-process or off-line using direct or indirect methods (Cook, 1980). Critical need for in-process tool and process monitoring has developed since computer numerically controlled (CNC) machines and automated machining centers have become more widespread (Koren, 1989). Monitoring individual machining processes in real time is critical to integrating those processes into the overall machining system. The in-process designation for a sensing method means that it is performed while metal is being removed (or during normal disengagement) without interrupting the process.

Off-line methods can be performed on the machine or away from the machine. In either case, off-line methods require either scheduling idle time or interrupting the process for measurement. In-process and off-line methods are effective in gathering important information about surface characteristics, but in-process methods are preferred. In-process monitoring provides real-time information concerning the machining process. This real-time feedback enables the machinist or operator to adjust the appropriate machining parameters in order to produce the desired surface roughness, reduce tool wear, and/or reduce the probability of tool breakage. However, monitoring or measurement conducted in-process or off-line would not be possible without the use of sensory devices.

Sensor technology is playing an ever-increasing role in the manufacturing environment for a wide variety of tasks, such as tool wear assessment, machine tool condition monitoring, and quantification of the surface finish. The demand for incorporating sensor technology into the production environment is being driven by increasing need to minimize manufacturing costs while simultaneously producing higher quality products.

Sensor technology can measure surface characteristics either directly or indirectly. Direct measurement methods using sensors include optical, electromagnetic, and ultrasonic methods. Direct sensors scan the workpiece surface directly and obtain surface roughness information as well as workpiece dimensions. However, these processes are limited because the presence of chips and/or cutting fluid blocks the line of sight they require to measure the workpiece surface. Indirect methods have been successfully used (Tsai, Chen, & Lou, 1999) to extrapolate the surface condition from vibration signals measured by the accelerometer or dynamometer. Indirect measurement is not impeded by the presence of chips and cutting, and thus is a more robust measurement method. For that reason, the present research employs an accelerometer sensor to indirectly measure surface roughness in real time.

Purpose of the Study

The purpose of this research was to develop a multilevel, in-process surface roughness recognition (M-ISRR) system to evaluate surface roughness in process and in real time. To develop this system precisely, the following key factors related to surface roughness during the machining process had to be identified: feed rate, spindle speed, depth of cut of the process, tool and workpiece materials, and so on. In addition, the dynamics of the machining process generate vibration between the tool and workpiece while the machining process is taking place. Vibration information was a key factor in the development of the M-ISRR system.

Research by Lou and Chen (1997) involving an in-process surface recognition (ISR) system resulted in the successful development of a surface recognition system. Their study attained approximately 93% accuracy with only one tool type and one work material. The M-ISRR system in the present research extends Lou and Chen's findings by using multiple tools and work materials. The present M-ISRR system provides a more robust R_a prediction system by incorporating multiple work materials, tools, and setup parameters. This system will provide the real-time surface roughness (R_a) values needed for in-process decision making in a more realistic industrial environment. A multiple regression analysis approach was used to develop the M-ISRR system.

Experimental Setup and Signal Processing

In any study, equipment and hardware play critical roles in conducting a viable experiment and collecting results consistent with the purpose of the study. A fundamental understanding of computer/machining equipment and data acquisition devices, which include proximity sensors, accelerometers, and signal converters (i.e., analog to digital or digital to analog), is important in understanding the activities conducted in this research. Accordingly, hardware and software used in this research are discussed in the next two sections.

Hardware Setup

All machining was done in a Fadal VMC (vertical machining center) with multiple tool-change capability. This machine is capable of three-axis movement (along the *x, y,* and *z* planes). Programs can be developed in the VMC directly or downloaded from a 3.5" diskette or data link. Information was collected using a 353B33 accelerometer and a Micro Switch 922 Series 3-wire DC proximity sensor. The accelerometer was used to collect vibration data generated by the cutting action of the work tool. The proximity sensor was used to count the rotations of the spindle as the tool was cutting. The proximity information then was graphed along with the accelerometer data, which enabled the identification of vibrations produced during different phases of the cutting sequence. Data from both sensors were converted from analog to digital signals through an Omega CIO-DAS-1602/12 A/D converter. The A/D converter-output was connected to a Pentium I personal computer via an I/O interface (see Figure 1).

Two power supplies were used. One power supply was used to amplify the signal from the accelerometer. This amplified signal was then sent to the A/D board. The second power supply was used to power the proximity sensor and circuitry. A signal was produced during the switched phase of the proximity sensor.

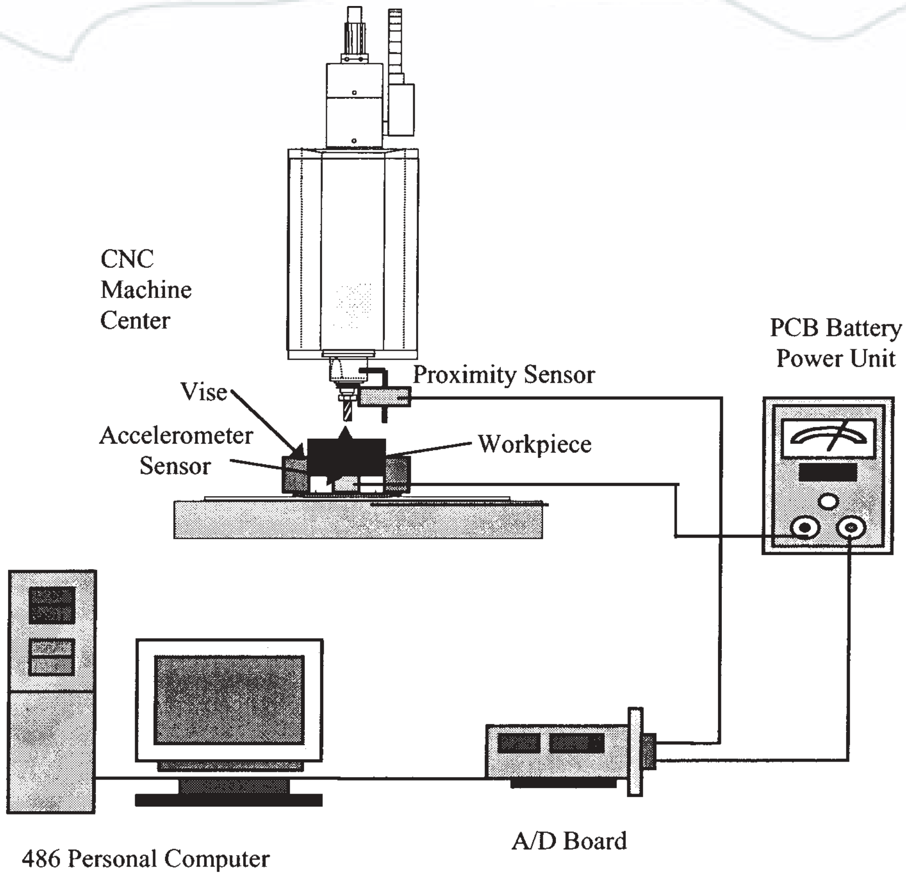

Figure 1. Experimental setup.

This signal was sent to the A/D board on a separate channel from the one used for the accelerometer signal.

The workpiece material used in this research was 6061 aluminum and 1018 steel blocks. The blocks were cut 1.00" x 1.00" x 1.00". Various feed and spindle speeds, depths of cut, work materials, tool materials and types, and tool diameters were tested.

The Federal PocketSurf stylus profilometer was used off-line to measure the surface roughness value of the machined samples. The surface finish measurements were made off-line with the roughness average R_a values rated in microinches (μi).

Software Setup

The software setup consisted of a CNC machining program, an A/D converting program, and a rotational average calculation program. The CNC machining program was written for cutting the workpieces at different spindle speeds, feed rates, and depths of cut. The A/D converting program was developed in C programming language. The rotational average calculation program calculated the vibration average per revolution. The Statistical Package for the Social Sciences (SPSS) version 8.0 software was used for computation and in the development of the multiple regression model.

Experimental Design of MR-M-ISRR

The multiple regression model contained seven independent variables. The seven independent variables were comprised of three categorical parameters and four interval parameters. The four interval parameters were (F) feed rate (X_{1i}), (D) depth of cut (X_{2i}), (S) spindle speed (X_{3i}), and (V) vibration average per revolution (X_{4i}) of the accelerometer sensor. The three categorical parameters were (TD) tool diameter (CX_{1i}), (TM) tool material (CX_{2i}), and (WM) work material (CX_{3i}). The regression equation for each design did not include *TD, TM,* or *WM*. These were categorical variables and could not be used as predictors.

The vibration average per revolution from the accelerometer was collected and converted to digital data through the A/D converter and stored. Figure 2 displays an example of the proximity and accelerometer data collected with a 1.00" cutting tool at a feed rate of

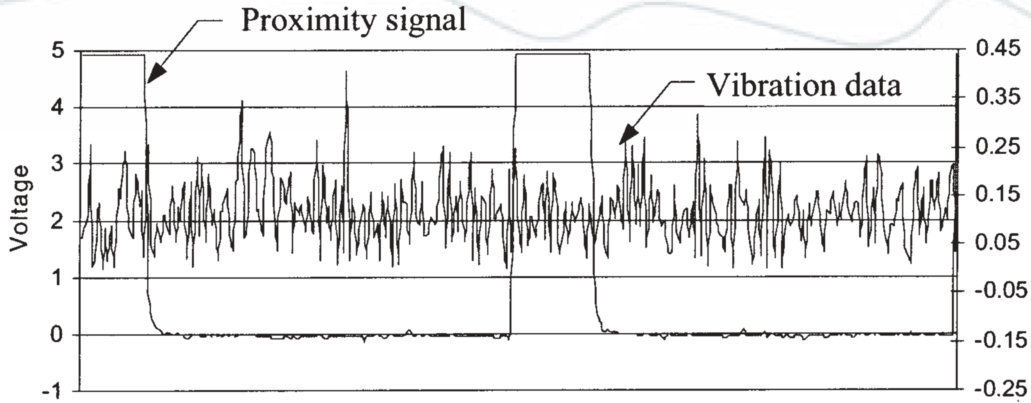

Figure 2. Sample vibration and proximity signal.

20 ipm. The following equation indicates the method of calculating the five average vibration data:

$$V_i = \sum_{j=(i-1)*k}^{i*k} |Vibration(j)|/k,\ i=1,2,3,4, and\ 5$$

where k represents the total number of data in each revolution, as indicated in Figure 2. For example, if $i = 1$, then the V_i was calculated through the vibration data points from point number 0 to point number k (to have a total of k data in one revolution). Vibration (V_i) was measured in units of voltage.

Four steps were used in developing the regression model:

1. Determine the regression model (Kirk, 1995): $Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \ldots + \beta_{h-1} X_{i,h-1} + \epsilon_i \ (i, \ldots, N)$ where Y_i=the predicted R_a value, $\beta_0, \ldots, \beta_{h-1}$ are the partial regression coefficients, $X_{i1}, \ldots, X_{i,hi}$ are the independent variables, and ϵ_i is the random error term with mean equal to zero and variance equal to σ^2_ϵ
2. Determine R, R^2, Adjusted R^2. The multiple correlation coefficient R is a Pearson product-moment correlation coefficient between the criterion variable Y and the predicted score on the criterion variable, $\hat{Y}$. R can be expressed as:

$$R_{Y\cdot 1,2\ldots K} = \sqrt{\beta_1 r_{Y1} + \beta_2 r_{Y2} + \ldots + \beta_K r_{YK}} = R_{y\hat{y}}$$

The proportion of the variation in the criterion variable that can be attributed to the variation of the combined predictor variables is represented by the square of the multiple correlation coefficient, or R^2.

3. Determine whether the value of multiple R is statistically significant. For multiple correlation, one can test the null hypothesis H_o: $R = 0$. An F statistic can be used to test this hypothesis by the following :

$$F = \frac{R^2 / k^2}{(1 - R^2)/(n - k - 1)}$$

where R = the multiple correlation coefficient and k = the number of predictor variables. If the computed value of F exceeds the critical value of F for a given level of significance, then H_o: $R = 0$ is rejected.

4. Determine the significance of the predictor variables. The regression coefficient can be tested for statistical significance by the value:

$$t = \frac{\beta_i}{S_{\beta i}}$$

where β_i = the regression coefficient and $S_{\beta i}$ = the standard error of the respective coefficient.

In this proposed model, the dependent variable was the surface roughness average value, R_a (Y_i). The structure of the multiple-regression, multilevel in-process surface roughness recognition (MR-M-ISRR) model is depicted in Figure 3. The proposed multiple-regression model was a two-way interaction equation:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{1i} X_{2i} + \beta_6 X_{1i} X_{3i} + \beta_7 X_{1i} X_{4i} + \beta_8 X_{2i} X_{3i} + \beta_9 X_{2i} X_{4i} + \beta_{10} X_{3i} X_{4i} + \epsilon_i$$

Three methods were used in developing

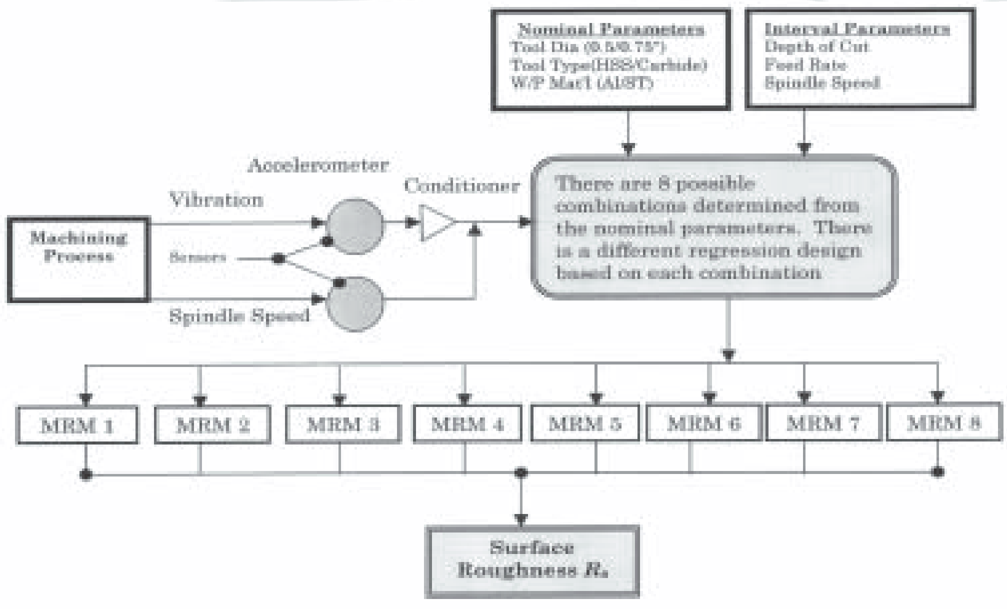

Figure 3. The structure of the MR-M-ISRR model.

the multiple-regression equations. First was the enter method, which entered all independent variables into the regression model regardless of the their significance. Second was the forward method, which entered the independent variables one at a time based on their significance. This method was built using only significant independent variables. Third, the forward method was used again except that the dependent variable R_a was transformed with the natural log function (e^x). This method was used to smooth the dispersion of the R_a values.

Analysis and Results

Eight multiple-regression equations were developed from the training data collected. A total of 384 experimental runs were carried out in order to develop the regression equation for the eight designs. Table 1 shows the parameters and settings of samples collected for developing the multiple-regression equations for each design. Within these experimental runs, some data were used for testing as well. In addition to these experimental runs, a total of 64 runs (as shown in Table 2) were performed to gather testing data for evaluating the accuracy of the proposed model. From each sample, five R_a readings were taken with the profilometer and five (V_i) averages were collected. The two-way interaction equation was used for each design in order to develop the best-fit model for surface roughness recognition.

The accuracy of the proposed MR-M-ISRR system was determined by calculating the deviation of the proposed regression model

Table 1. Parameters and Settings for the Training Data

Feed (ipm)	Depth (inches)	Rpm
8	0.01	1500
11	0.02	1667
14	0.03	1833
16		2000

Table 2. Parameters and Settings for the Testing Data

Feed (ipm)	Depth (inches)	Rpm
10	0.015	1583
14	0.025	1917

Table 3. Multiple Regression Equations for Design (*j*)

Design (*j*)	Regression Equation
1	Ra_1 = -48.674 + 6.034X_{11} + 1390.841X_{12} + 0.03027X_{13} - 197.771X_{14} - 0.002765$X_{11}X_{13}$ - 0.969$X_{12}X_{13}$ + 0.08889$X_{13}X_{14}$ + 33.483$X_{11}X_{13}$ + 0.704$X_{12}X_{13}X_{14}$.
2	Ra_2 = 77.896 + 12.232X_{21} - 3660.757X_{22} - 0.0572X_{23} - 2680.321X_{24} - 0.003425$X_{21}X_{23}$ + 3.747$X_{22}X_{23}$ + 2.164$X_{23}X_{24}$ - 93.377$X_{21}X_{22}$ - 91.797$X_{22}X_{23}X_{24}$ + 117816.740$X_{22}X_{24}$.
3	Ra_3 = 3.927 + 0.04071X_{31} - 0.0001686X_{33} + 144.76$X_{32}X_{34}$.
4	Ra_4 = e** (-6.618 + 0.162*X_{41} + 573.629X_{42} + 0.005809X_{43} + 271.141X_{44} - 0.00003366$X_{41}X_{43}$ - 0.34$X_{42}X_{43}$ - 0.149$X_{43}X_{44}$ - 14249.05$X_{42}X_{44}$ - 1.801$X_{41}X_{44}$ + 8.248$X_{42}X_{43}X_{44}$).
5	Ra_5 = 53.837 - 0.437X_{51} - 1878.232X_{52} - 0.02558X_{53} -204.241X_{54} + 0.0006958$X_{51}X_{53}$ + 0.961$X_{52}X_{53}$ + 0.144$X_{53}X_{54}$ + 3.681$X_{51}X_{52}$ + 18430.247$X_{52}X_{54}$ - 5.646$X_{51}X_{54}$ - 9.806$X_{52}X_{53}X_{54}$.
6	Ra_6 = e**(4.48 + 0.0004797X_3 - 0.00004858X_1X_3 + 0.0106X_2X_3 - 0.009122X_3X_4 - 4.378X_1X_2 + 547.698X_2X_4 + 1.627X_1X_4 - 0.209$X_2X_3X_4$).
7	Ra_7 = 21.399 + 2.078X_{71} + 719.455X_{72} + 0.0004339X_{73} + 562.564X_{74} + 0.00001519$X_{71}X_{73}$ - 0.295$X_{72}X_{73}$ - 0.05761$X_{73}X_{74}$ - 0.146$X_{71}X_{72}$ + 1775.765$X_{72}X_{74}$ - 29.665$X_{71}X_{74}$ - 2.835$X_{72}X_{73}X_{74}$.
8	Ra_8 = -48.567+5.364X_{81} + 7684.154X_{82} - 233.178X_{84} - 0.494$X_{82}X_{83}$ + 0.828$X_{83}X_{84}$ - 348.446$X_{81}X_{82}$ - 29.838$X_{82}X_{83}X_{84}$

(Ra_{ij}) from the actual profilometer measurement (Ra_{ij}) taken from each sample. The deviation for each testing sample under design *j* was denoted by $\forall_{kj}$ and was defined as follows:

$$\o_{kj} = \frac{|Ra_{ij} - Ra'_{ij}|}{Ra_{ij}}$$

After the deviation of each testing sample under design *j* was determined, the average deviation of each design (*j*) was calculated as follows:

$$\bar{\o}_j = \frac{\sum_{k=1}^{m} \o_{kj}}{m}$$

where *m* = number of samples with each design (in this case, *m* = 8). After the deviation of each design was calculated, the overall average for the MR-M-ISRR system was defined as follows:

$$\bar{\bar{\o}} = \frac{\sum_{j=1}^{n} \bar{\o}_j}{n}$$

where *n* is the number of designs (in this case, *n* = 8).

Results and Summary

Eight multiple regression designs were developed successfully with the resultant equations displayed in Table 3. The recognition accuracy of this proposed MR-M-ISRR system is summarized in Table 4. Designs 2 and 7, both using the forward method, resulted in the least deviation from the actual R_a value. Design 4 had the third least deviation from the R_a value. The method used for Design 4 was the forward method with R_a transformed.

The overall MR-M-ISRR system demonstrated 82% accuracy of prediction average, establishing a promising step to further development in in-process surface roughness recognition systems. In consideration of the MR-M-ISRR systems' less-than-exceptional recognition accuracy, this research does support the use of regression analysis techniques to model dynamic machining processes. Improved accuracy utilizing regression analysis techniques is achievable but will require a dramatic increase in experimental sample sizes involving the use of multiple tools and materials. Furthermore, an alternative method for developing an in-process prediction system should be considered. Alternative methods demonstrating learning capability within the prediction system are most desirable. The use

Table 4. The Overall Accuracy for the MR-M-ISRR System Using the Testing Data Sets

Design (*j*)	Design Configuration	Average Deviation for MR Model	Samples (*m*)
1	$TD_1TM_1WM_1$	.0906	8
2	$TD_1TM_1WM_2$	.1211	8
3	$TD_1TM_2WM_1$	.2748	8
4	$TD_1TM_2WM_2$	.2200	8
5	$TD_2TM_1WM_1$	.0482	8
6	$TD_2TM_1WM_2$	.2586	8
7	$TD_2TM_2WM_1$	.1006	8
8	$TD_2TM_2WM_2$	.3497	8
Total $n = 8$		18.3%	64
Accuracy		82%	

of neural network algorithms or fuzzy net methodologies provides feasible alternatives for surface roughness recognition model development. In the development of an ISRR system, similar research utilizing neural networks and fuzzy nets has demonstrated commendable results. Therefore, continued research focused in ISRR system development is promising.

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The Implications of Service-Learning for Technology Studies

James E. Folkestad, Bolivar A. Senior, and Michael A. DeMiranda

Throughout their educational careers students are taught that there are right and wrong answers. Students are also rewarded for finding correct answers and discovering solutions ahead of their classmates. This type of conditioning, or lack of preparation, often leaves college graduates struggling in a workplace that no longer rewards people for the "right" answer but rather rewards those who can get projects accomplished while working with others. Having the right answer and getting tasks accomplished are often mutually exclusive events. These are important skills and learning objectives that educators often fail to deliver.

Technical educators should be emphasizing a student's social attitude toward working with others while simultaneously providing the formal knowledge required for technical literacy. While a good academic record is part of stated requisites, industrial leaders are also seeking new hires who can work with others to affect change. Although this is important, there are few pedagogical tools to foster students' competency in this area.

This article describes a pedagogical approach called service-learning. Although it appears that this pedagogical approach is relatively new to those teaching in the area of technology studies, it must be acknowledged that similar work-based or project-based pedagogical approaches have been studied by previous authors of this journal (Harnish, 1998; Resnick, 1987). Service-learning is unique from these work/project-based approaches because of the service orientation and because it challenges students to engage in a high level of reflection and has an important goal of helping students build civic responsibility and social awareness skills. The philosophy and elements of the service-learning pedagogical tool are discussed, along with some of the implementation issues found while integrating it into a technology management course at Colorado State University.

Service-Learning

The National Society for Experiential Education has defined service-learning as "any carefully monitored service experience in which a student has intentional learning goals and reflects actively on what he or she is learning throughout the experience" (Furco, 1994, p. 2). This definition requires some further discussion, since the term *service-learning* has been applied to many forms of experiential education. Figure 1 shows the distinctions among experiential programs.

Figure 1 also shows how service-learning requires that both the recipient and the provider benefit from the experience. This is a fundamental distinction between service-learning and community service or volunteerism, where the provider of the service does not intend to realize any personal gain. On the other hand, an internship makes the service component an accessory to the study of technology, or may be absent altogether. A mutually beneficial situation could result, for example, from engaging a manufacturing class to design a toy for the Toys-for-Tots holiday gift project. While a community's children will benefit from the finished toy, the students will also benefit from this service-learning and structured classroom experience. Furthermore, an important element of service-learning is the need for a deliberate learning goal. In the Toys-for-Tots example, if students would simply produce toys without any programmatic design from the class instructor,

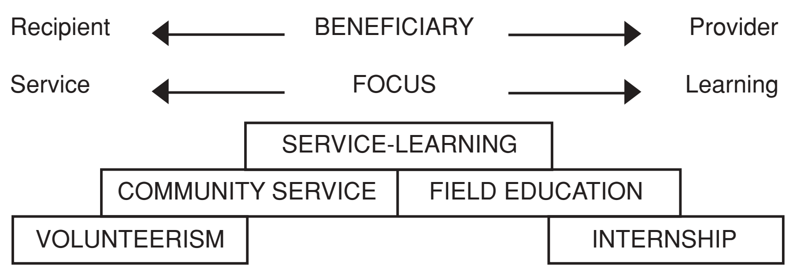

Figure 1. Distinctions among service programs (Furco, 1996).

the experience would qualify as volunteerism, but not as service-learning.

The need to introduce reflection and self-regulation into the learning experience is perhaps the most neglected component of service-learning. However, it is a well-established fact that we learn through combinations of thought and action, reflection and practice, theory and application (Kendall, 1988). Effective learning can be achieved while discussing intellectual, civic, ethical, moral, cross-cultural, career, or personal goals (Kendall, 1990; Lisman, 1998). Using the Toys-for-Tots example again, some valid discussion topics may be: Why should underprivileged families be given toys during the holiday session? How do other countries deal with the problem of poverty? How could the cost of manufacturing the toys be reduced? How should society deal with the issue of poverty during a time of extreme economic prosperity? Should product safety regulations be relaxed for this type of manufacturing? Part of the instructor's duties is to think in advance and discuss such topics with the students. Reflection should not be postponed to the end of the experience, but be part of the learning experience as it unfolds.

Service-learning should also include a strong reflective and self-regulation component that directs students to discuss current social issues and encourages them to talk about values and what being an active member of society means to them (Lisman, 1998; Rhoads, 1997).

Purpose: What Service-Learning Has to Offer Technology Studies

In order to appreciate the need and advantages of service-learning and similar hands-on pedagogical approaches, it is necessary to reflect on the state of higher education. Recent articles have criticized the current environment in institutions of higher education for their "indifferent undergraduate teaching, overemphasis on esoteric research, failure to promote moral character and civic consciousness, and narrow focus on preparing graduates for the job market" (Jacoby, 1996, p. 4). Also, in a 1999 Society of Manufacturing Engineers (SME) education report a group of industry education leaders identified competency gaps among newly hired college graduates in the areas of development of personal character and the ability to work well with others. Deficiency areas included communication skills, teamwork, personal attributes, and an ability to affect change. The communication skills included presentation skills, written report generation capabilities, graphic computer software usage, and meeting organization and facilitation.

Service-learning combines all the advantages of expanding knowledge acquisition with practical exposure. In virtually all modern learning theories, the need for such hands-on opportunities is a central component. Bloom's taxonomy (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956), generally recognized as a central element of modern learning theory, identifies six major divisions of the cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. These are useful to demonstrate the richness of service-learning. Solving a typical service-learning problem requires a deeper understanding of the meaning of technical alternatives than the simple aggregation of technical facts (comprehension). It also requires the application of these facts in a particular concrete situation (application): the breaking down of a relatively complex problem into manageable pieces and then finding a wholistic solution to these pieces (analysis and synthesis). A reflective assessment of the problem and the applied solution (evaluation) is a central element of the service-learning. Components of other learning theories such as Perry's theory of development of college students and Kolb's learning cycle also support service-learning (Culver, 1985; Kolb, 1984; Perry, 1970).

The strengthening of character through service is discussed less in the literature. The manufacturing industry, however, offers testimony of improvement and even dramatic change in the character of many participants in internships and similar practical experiences that are arranged through Colorado State University. In addition, *Time Magazine* conducted a survey of 608 middle and high school students with some previous exposure to community service. It found that 75% of the students said that they "learned more during community service than in a typical class" (Cloud, 1997, p. 76). Although judgment must be exerted to extrapolate these results to all technology study students engaged in service-learning, Colorado State University's Industrial Technology Management (ITM) students show that Bloom's taxonomy seems to hold true insofar as the education value of service in general.

The Higher Education Research Institute at the University of California, Los Angeles conducted a number of studies on the impact that the service-learning experience has on the development of undergraduates. One study involving 3,450 students attending 42 institutions concluded that student participants in service-learning were more likely than those in non-service-learning classes to strengthen their commitment to participating in community action programs, influencing social values, and promoting racial understanding. In the area of life skills, service participants showed greater positive changes in understanding community problems, knowledge of different races/cultures, interpersonal skills, understanding of the nation's social problems, the ability to work cooperatively, and skills in conflict resolution. In addition, students who have had a community service course tend to carry these attributes with them over the long term. The strongest of these long-term attributes was related to the students' commitment to volunteerism and community activism (Sax & Astin, 1997). Eyler, Giles, and Braxton's (1997) study on the impact of service-learning on college students found similar effects including that service-learning was a predictor of students valuing a career helping people and that students volunteering time in the community resulted in students being more active within the political system. A positive impact on skills of political participation, tolerance, communication, issue identification, and critical thinking were evidenced.

Although these studies provide evidence of the impact of service-learning, a common objection to this pedagogy is that service-learning consumes time and energy that students may otherwise devote to academic pursuits. Sax and Astin (1997) asserted that "this argument has been laid to rest by the results of our longitudinal analysis which reveal significant positive effects on all ten academic outcomes included in the study" (p. 27).

Toys-for-Tots: Implementing Service-Learning at Colorado State University

An attempt to integrate service-learning into the manufacturing technology curriculum was made by author James Folkestad, who modified the traditional delivery of Process Planning and Costing, a required junior course in the ITM curriculum at Colorado State University. The course is offered during the spring semester and has an average enrollment of 25 students for each section. Students enrolled in Process Planning and Costing typically have already taken courses on quality improvement and safety. A traditional lecture/laboratory format, slightly adjusted to accommodate each instructor's teaching style, had been the standard for more than 10 years. Folkestad chose to implement a Toys-for-Tots experience into Process Planning and Costing because the course content aligned with the service project although service-learning can be introduced in other courses, such as in a capstone experience. This required the development and planning of a toy using a planning process that was directly related to the learning objectives of the Process Planning and Costing curriculum content. In order for students to fully understand the class concepts, they were required to work with various stakeholders. Stakeholder diversity is similar to what students would experience working in industry. The Toys-for-Tots program brings diversity to the class by including stakeholders such as parents, students, and professors who have dissimilar backgrounds and usually different and sometimes conflicting demands.

A local community service agency called Even-Start Learning Center had been involved with the ITM program for 11 years, receiving toys that were manufactured by students and given to economically disadvantaged families during the December holiday session. Until 1997 toy designs had remained the same and were designed by retired faculty members and former students. Although these toys were greeted with great excitement each year, the program needed new ideas, toy designs, and production plans.

The goal of the Process Planning and Costing students was to provide designs for new toys and toy production plans. Course requirements included establishing processes, planning, and determining costing for a manufacturing project. These basics include "best practices" in the definition and control of the scope, costs, quality, and time. The students were introduced to best practices and then expected to apply them to the service-learning project. These best practices included problem definition and statements, project mission and mission hierarchy, scope definition and control techniques, stakeholder

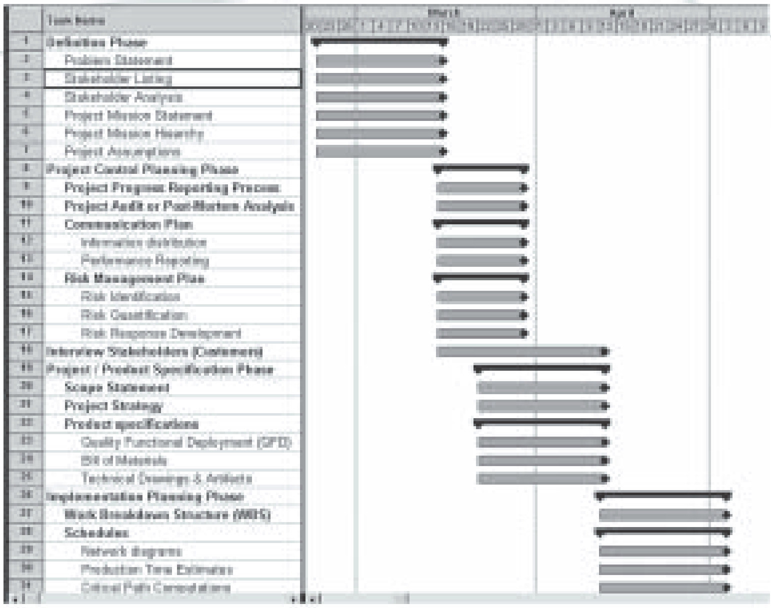

Figure 2. Project milestones and deliverables.

identification and interviews, quality functional deployment, duration estimating and scheduling, schedule control, and project progress reporting. All of these items were documented in a project notebook and given to the manufacturing student club for toy production (Folkestad, 1999).

The class began the project approximately halfway through the spring semester with four major deadlines. Figure 2 shows the project schedule, which outlines the project deadlines and project deliverables. The project was assigned halfway through the semester to allow students to complete the requirements and to avoid end-of-semester pressures.

Students worked to develop their project notebooks (which were the course's final project) in teams of four to five students. Students were randomly assigned to teams in order to distribute talent and friends and to simulate the workplace where employees are required to work with a variety of individuals (motivated, not motivated, etc.). Each team was responsible for designing one toy that would meet all stakeholder demands. The first task was to establish a list of stakeholders, including the children, their parents, teachers, and internal university stakeholders such as manufacturing club members (those individuals responsible for manufacturing the toys) and the department's machine shop director. Figure 3 represents an example of a

STAKEHOLDER LISTING AND ANALYSIS

1. **Project Manager & Dr. James Folkestad** - Must be aware of the progress of entire project. Information needs consist of project progress reports and audits throughout the planning process.

2. **Parents** - Must be certain that product conforms with cultural and moral beliefs that the parents are trying to teach. Initial consultation will be done to narrow design specifications for product. Information needs consist of final product design(s) for verification and/or suggestions.

3. **Even=Start Family Center** - Must be certain that product does not violate company standards or applicable laws. Initial consultation will be done to narrow design specifications for product. Information needs consist of final product design(s) for verification and/or suggestions.

4. **Design Team** - Must be aware of cost and time factors as well as product specifications and design constraints. Information needs consist of milestones for design(s) and manufacturing constraints.

5. **Marketing Team** - Must be aware of design features and project milestones. Information needs consist of consultation with parent(s), final product design with features, and dates needed for customer confirmation.

6. **Manufacturing & Dr. Steve Schaeffer** - Must verify that product can be manufactured using tools available. Information needs consist of product design(s), manufacturing process assumptions and material list.

7. **Suppliers** - Must be certain that suppliers will be able to meet the cost and time restrictions that production will require. Information needs consist of delivery dates, lot sizes and payment process.

8. **Notebook coordinator** - Must be certain that thorough documentation is given to the project manager and Dr. Folkestad on time. Information needs consists of all documentation required for notebook fulfillment.

Figure 3. Stakeholder listing and analysis.

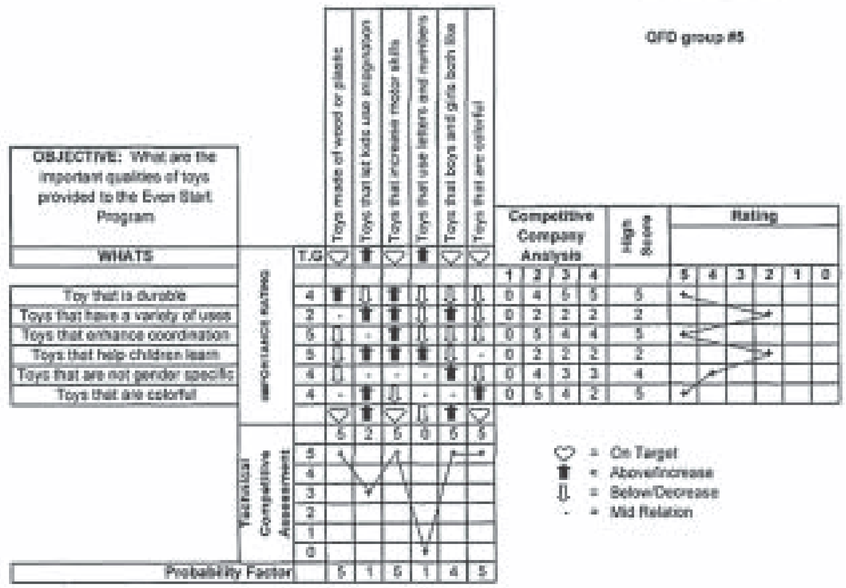

Figure 4. Quality functional deployment (QFD) chart.

stakeholder analysis document. This stakeholder analysis led the students into the service-learning activity requiring them to work closely with key stakeholders within the Even-Start Program.

The next step was a field trip to the Even-Start Learning Center to conduct the stakeholder interviews. Although all teams identified the children as major stakeholders, it was agreed that they would not be interviewed to preserve the surprise of the holiday celebration. However, the parents and teachers of the children were interviewed. During this interview, students were instructed to capture the customer's voice in their own words. An example of a typical statement was, "My child likes the toys that are bright and have moving parts." Comments such as this were then inserted into a quality functional deployment (QFD) chart to translate the "voice of the customer" into product/engineering specifications as shown in Figure 4.

During these interviews the students learned several facts about their customers' interests. The parents interviewed spoke limited English. Although a translator was required, students and parents overcame this barrier by using paper and pencil to sketch ideas and gather information through drawings. Many of the parents wanted their children to have traditional toys similar to those found in Mexico. These included items ranging from a simple wooden noisemaker to an intricate hand-carved wagon and horse. One of the comments was related to a previously produced toy, a (wooden) duck. One parent expressed her concern that she had six children and that for the past three years at least half of them had received a duck. Her concern, humorously expressed, was that she was running out of room for ducks.

In general, several reflective sessions are recommended for a service-learning experience. The fact that only one was conducted in this case reflects more the instructor's inexperience in this field than any deliberate decision. Overall, the service-learning experience was very positive for the majority of the students in the class. In the student evaluation of the course at the end of the semester, service-learning was consistently considered to have enhanced the learning of the course contents.

Challenges to Service-Learning and Implications

The first challenge to consider regarding service-learning comes from the fact that it has only recently been applied to technology fields such as industrial technology management. In areas of study such as social work, students are expected to gain a deep understanding of their community. There is an evident link between service-learning and their educational goals. This is not often the case in technology studies. An instructor trying to implement service-learning in a course has the burden of proof to convince colleagues of the merits of this approach. An extensive literature search was conducted before implementing Folkestad's project, and it became apparent that another consequence of this absence of precedent is that there is no instruction or lessons learned specifically for technology education. In contrast, and of great importance, is the sizable body of literature offering insights about experience gained from implementing service-learning in the social science areas.

Another challenge for new service-learning instructors is the nature of the reflection component. A few possible topics that were mentioned previously (i.e., why should underprivileged families be given toys during the holiday session?) may seem too ideological to technology instructors and distant from the scope of their traditional curriculum. However, civic and industrial leaders are emphasizing the importance of this type of social awareness. Discussing social issues is an important component of service-learning, and perhaps the awkwardness of dealing with social issues is the best testimony of the chronic deficiency of the technology studies field to address this important area.

The above aspects can be overcome by a willful instructor. However, other issues are generally beyond the control of anyone in particular (Senior, 1999). An issue may be identifying an appropriate project in the first place. In Senior's (1999) case study, the Service Integration Project staff at Colorado State University identified a project and provided the initial contacts. Senior reported that several of these contacts led to projects that didn't fit the objectives of his course and were discarded after interviewing representatives from the involved agencies. Furthermore, several of the project's timelines did not meet the course's semester duration and could not be accommodated. Conversely, the Toys-for-Tots activity is well suited for a service-learning project. First, the toys can be designed and the project notebooks developed within a semester course and well in advance of toy production. In addition, the toys are produced annually and are delivered at the end of the fall semester. Finding a service-learning project with similar time demands is critical to success. Instructors should identify a project that can be completed within a standard academic timeframe and that offers a level of year-to-year consistency.

Assistance in implementing service-learning is readily available on many campuses. Instructors are likely to have access to some level of institutional support through their office of community services (or equivalent). There, they can find literature and get help in locating suitable service projects, modifying the course syllabus, and other initial tasks. For example, Colorado State University offers grants to help in the start-up of such efforts. In general, service integration seems to have political momentum. The state of Maryland now requires 75 hours of community service from all high school students. Miami began requiring 75 hours in 1996, and Chicago began requiring 40 hours in 1998 (Cloud, 1997). Although revolutionary by American standards, these requirements are still shy of the more extensive service system that has been in place for decades in Germany, Austria, and other European nations. Furthermore, the current federal administration is pushing for service-learning as a requisite for federal grants and local service programs (Cloud, 1997).

Such momentum does not guarantee ultimate success. In an article dealing with community service entitled "Involuntary Volunteers," Cloud (1997) explained that even though 91% of students polled agreed that they should be "encouraged" to participate in community service, only 36% think that they should be required to participate. At the more immediate level, untenured instructors may face the dilemma of keeping their teaching within the comfortable realm of traditional lecturing, or entering into relatively uncharted territory with service-learning. As Morton (1996) noted, "the growth of service-learning will require that executive officers, from department chairs to presidents, find ways to recognize and reward different teaching styles, assign equitable teaching loads…and otherwise protect and promote the careers of faculty who wish to commit to the integration of service and learning" (p. 289).

Service-learning presents a uniquely positive opportunity for technology studies students and their community. Significant nationwide studies do indicate the positive impact this type of program has on students within a variety of educational disciplines. The members of Colorado State University's ITM industrial advisory board have stated that they need people with a combination of technology skills and strong personal character; service-learning has helped promote these desirable character traits.

An essential element to the adoption of service-learning for technology studies is the creation of a body of literature specific to this discipline. The publication of new case studies should be encouraged to achieve this objective. This case study shows encouraging, though informal, indications that the students in Process Planning and Costing benefit from the experience. Future research should examine the hypothesis that service-learning indeed improves technology education and promotes civic responsibility and awareness of technology studies students.

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Portable Document Format (PDF)—Finally, a Universal Document Exchange Technology

Wan-Lee Cheng

Electronic File Exchange

As you well know, electronic and computer technologies have revolutionized the graphic/visual communications industry over the past 24 years. Word processing, computer graphics, desktop publishing, digital media, and the Internet have completely changed the communication flow in every environment. Now people can enjoy producing and receiving high quality, color realistic, and information rich visual images in affordable forms. However, despite the rapid technological advancement, there have always been information exchange problems between users because of incompatibility among different computer platforms and software programs.

Many approaches in both hardware and software development have attempted to solve electronic file exchange problems, but none have proved promising until the development of the Portable Document Format (PDF) in 1993. Hamilton (1999), in his article "PDF Output," pointed out the value of PDF:

> After wandering in its infancy, PDF is now entering the commercially viable stage of its life. Having been initially pitched to the corporate/office communications and online publishing markets as a stable, cross-platform tool for document distribution, it is finding a home with Acrobat's core audience in publishing, prepress, and commercial printing. (p. 26)

One of the keys to making information exchange work well is to have a universal vehicle to deliver electronic data without losing its fidelity and integrity. Therefore, developing an exchangeable file format has been quite diligently carried out by the computer industry. Some of the resulting accomplishments such as *Text Only, Rich Text Format, Initial Graphics Exchange Specification (IGES), Drawing Interchange Format (DXF), Tagged Image File Format (TIFF), Joint Photographic Experts Group (JPEG),* and *Graphics Interchange Format (GIF)* did make file transfer possible, but they only worked for particular kinds of image files and did not solve all problems.

For example, Text Only and Rich Text Format are useful for word processing files. Even though problems about exchanging data among users of different word processing software mostly get solved, type fonts, styles, and text-formatting requirements may not all be converted properly. Other solutions—such as IGES and DXF—cater to computer-aided drawing files that exchange vector-based data, while TIFF, JPEG, and GIF are designed for pixel-based image conversion.

PDF, however, brings new promise. Finally, a software technology provides a common file format for computer users of Macintosh, PC Windows, and UNIX platforms, allowing them to communicate regardless of operating system, hardware configurations, or even native application software. Kessling (1998) clearly summarized the purpose behind the development of PDF:

> PDF is the ground-breaking format of the Adobe Acrobat product line, which celebrated its market debut in 1993. Its intended purpose was the effortless exchange of electronic documents without having to worry about platforms, applications, versions, or fonts. (p. 213)

Features of PDF

PDF allows information containing text, graphics, sound, animations, and movies to be faithfully delivered via digital means. Adobe Acrobat—actually a suite of software—converts documents to PDF and allows users to view the file contents with their original visual richness across computer platforms.

Furthermore, a PDF document can later be converted back to the PostScript format, then go through the Raster Image Process (RIP) for printed media reproduction. (RIP is an essential process to transform digital images to printable visual images in any printing process.) In fact, the latest development of PostScript Level 3 allows a PDF file to be RIPped directly without going through the extra PostScript converting process. To RIP a PDF file directly will not only increase productivity but also reduce potential errors by eliminating the PDF to PostScript conversion process.

Many large advertising, book, magazine, and commercial printing businesses have adopted PDF for their digital workflow in both prepress and printing production. TC Advertising, an insert printer; McNughton and Gunn, a book printer based in Salina, Michigan; Exped Printing in New York City; and R.R. Donnelley are just some of the companies across the United States that have already implemented PDF standards in their business operations (Hamilton, 1999).

Another great benefit of using PDF is the much reduced file sizes. For example, the file size of a typical eight-page, two-color newsletter can be reduced from 1.7 MB in its native Adobe PageMaker format to only 117 KB after it is distilled to PDF. Intranet and Internet users have recognized the small file size advantage for effective online communications for a long time. Because of its simplicity and portability, printing and publishing industries along with other businesses have already relied on PDF as a principal solution for archiving documents and storing them (Messenger, 1999).

Although PDF is still growing, there is no doubt that it will become the mainstream technology for electronic communications, document distribution, and printing/publishing workflow. Furthermore, its editiblity, portability, accessibility, and flexibility apply to both electronic media and print media for personal and professional use. As John Deubert (1999), president of Acquired Knowledge suggested, PDF will displace PostScript and TIFF/IT as the primary file format for document distribution for printing/publishing, CD-ROM, and Internet web-based applications. In fact, the Committee for Graphic Arts Technologies Standards (CGATS), accredited by the American National Standards Institute (ANSI), is developing the standard for using PDF files in composite data exchange (Witkowski & Kew, 1999). Figure 1 illustrates the sources, processes, and typical applications of PDF.

Adobe Acrobat—PDF Software

Several software developers were engaged in the development of PDFs in the early 1990s. Adobe Systems developed Acrobat and defined its PDF as cross-platform and independent of native application software. Through its distilling process, a PostScript file can be converted to a PDF file containing embedded type fonts, compressed image elements, and many original graphic characteristics. Anyone who receives the document can then view it in its original state, regardless of the operating system of the sender (Mac OS, PC DOS, Windows, or UNIX), the availability of native application software, or the type of font files involved.

Acrobat was indeed designed for multiple applications. According to Stoy (1999),

> Adobe has historically recognized four major applications for PDF files: first are files to be downloaded from online sources, second are files to be distributed on CDs, third are files directed toward output devices such as inkjet and laser printers and digital copiers, and fourth are files directed toward conventional printing prepress or computer-to-paper devices such as Xeikon DCP-1, Agfa Chromapress, and Indigo e-Print. (p. 27)

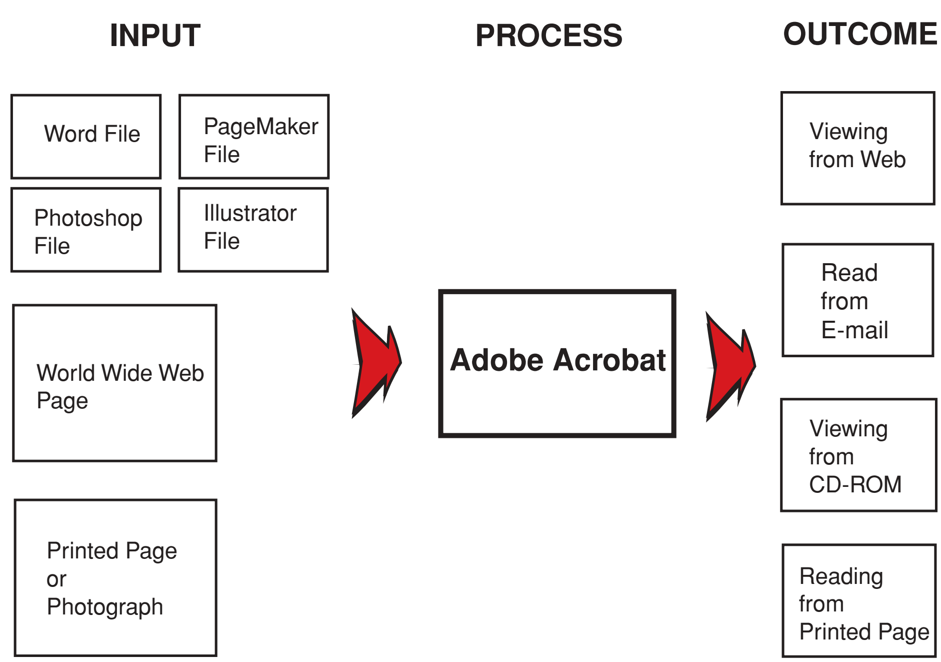

Figure 1. Typical PDF process and applications.

In 1996, Adobe Acrobat 3.0 was released, which was a breakthrough from previous Acrobat versions. It not only solved many problems, such as errors during distilling complicated vector-based entities and incapability of integrating into the prepress workflow, but it included functions to handle high-end printing needs. With the Acrobat 4.0 version upgrade in 1999, it further refined many of the weaknesses that 3.0 could not address, such as TrueType font support, editing capability, and color management. Acrobat's latest version (Acrobat 5.0) again enhanced its functions of editing, large format accommodation, and Asian font support, which not only increased the output power but also has made it a truly universal documentation exchange tool.

Adobe Acrobat consists of the following six parts:

- *Acrobat Reader* is a free software download from the Adobe web site (http://www.adobe.com). It is also distributed with other Adobe application software. It is a viewing program, so users can open a PDF file and navigate through pages of the document and even print out hard copies.
- *Acrobat Distiller* is a program that converts a PostScript file to a PDF file. After a document is created with a native application software, then saved as a PostScript file, Distiller converts it into PDF file format. Many of the latest Adobe applications, such as Photoshop, Illustrator, and PageMaker, are equipped with a built-in distilling function to handle the one-step direct conversion from the document itself to PDF. However, many non-Adobe programs still need to go through the PostScript conversion process.
- *Acrobat* is both a viewing and editing program. Acrobat provides many useful editing features to an already existing PDF document. For example, inserting pages, replacing a page with another page, cropping a page, deleting pages, creating a note, editing text, and adding annotations are all available for users to customize PDF documents. There are also many third-party plug-ins, which can be used with Acrobat to enhance the editing functions.
- *PDF Writer* is a printer driver that converts native documents into PDF files. Instead of sending the document to a computer printer for a hard copy, selecting PDF Writer as a printing device creates a soft copy of the PDF file. This method of creating a PDF file is the simplest method. Even so, it must be noted that PDF Writer has fewer options than Acrobat Distiller.
- *Acrobat Capture* is a plug-in item that can be executed within Acrobat. The function of Capture is to allow scanned text images to be converted to a character-based PDF document. Therefore, text editing can be applied to the document.
- *Acrobat Catalog* is a program that indexes large volumes of PDF files for easy access at a later time. Similar to the card catalog system in a library, it lets the user easily locate a particular PDF document via the search engine in Acrobat Reader or Acrobat. Catalog is an essential tool for archiving PDF files in a structured manner.

Creating a PDF File

Figure 2 explains how PDF files can be created.

There are three methods to convert a native application document to a PDF file.

1. To use PDF Writer, you must have the PDF Writer driver installed and select it from the Chooser. Then, choose PDF to print your document. This is a convenient one-step process. However, because of some limitations, use this method only when the document contains mainly text and a small amount of graphics.
2. To use Acrobat Distiller, save the file in PostScript. The PostScript file will then be distilled into the final PDF document. Although this method requires extra steps for the conversion, the resulting PDF document will be most accurate and reliable. In general, if a document contains a sophisticated design or rich visuals, especially with Encapsulated PostScript images, use this method.
3. Some application software (Photoshop, Illustrator, PageMaker) have a built-in feature to create a PDF version of the document directly within the applica-tion. Use this method when it is available.

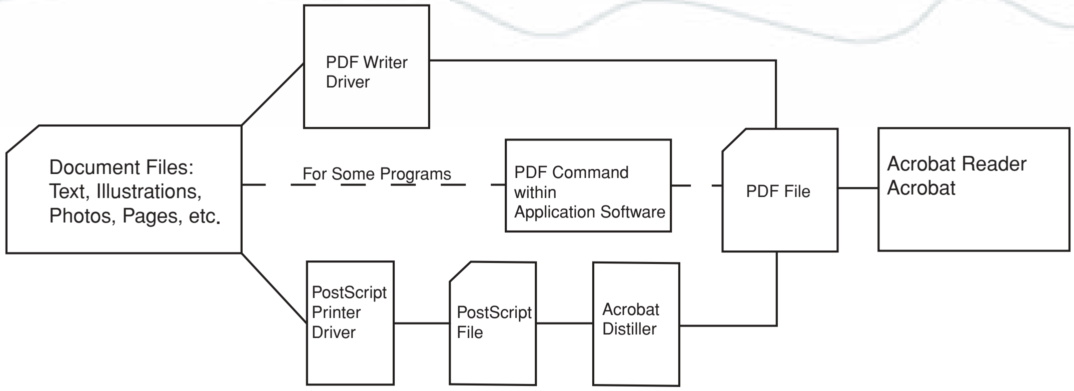

Figure 2. Typical workflow of creating a PDF file.

4. A scanned document can, likewise, be converted. A built-in Capture function, which is similar to OCR, can convert picture mode of scanned-in type-matter to a character mode text document.

Maximizing PDF's Final Outcomes

In order to preserve the accuracy of the graphic elements and the integrity of the original design, the following key control factors must be set up properly:

1. *Optimization:* Screen Optimized, Print Optimized, and Press Optimized options are available to enhance the user's outcomes.
2. *Compression and Quality:* While the size of a file is an important factor for storage and data transport, the image's integrity is essential for high-quality print reproduction. Select the best possible level of compression according to the types of images and the intended end use of the document. In general, for continuous tone, with color bitmap images used in printed matter, choose High or Maximum Quality. Medium or Low Quality is adequate for Web- and screen-based display.
3. *Font Embedding:* Retaining the exact font information of all original design is critical. The Font Embedding function in both PDF Writer and Acrobat Distiller enable PDF documents to maintain the exact fonts and format information in the original file. Therefore, the PDF document will reproduce the same type characteristics of the original, regardless of the computer platform used and/or the availability of such fonts in the system. (To make sure that all type will be accurately reproduced and displayed, select the Embed All Fonts option.)

Applications of PDF Documents

Applications of a PDF file can be as simple as exchanging files between individuals or as sophisticated as serving a major role in the automated printing/publishing workflow. Following are some examples of PDF applications:

1. *File exchange:* One can send a PDF to another person for viewing/reproducing the document in its original form.
2. *Proof or hard copy:* To order a commercial-quality proof or hard copies from a service bureau, PDF is the most trouble-free file format for the process.
3. *Presentations:* PDF can be used for instructional or marketing presentations. The presentation can be kept in its original design and form even if the hardware and/or software that created the document are not available.
4. *Electronic publications:* Newsletters, magazines, instructional manuals, and even books can be published on CD-ROMs or via the Internet with PDF files. Interactive user interfaces and multimedia features can be created in the publications to make readings more interesting and enjoyable.
5. *Archives:* Because of the smaller file size of PDF files, images or text documents can be archived with the use of PDF to save considerable storage space.
6. *Designer-client interaction:* Graphic designers can send PDF comprehensives to their clients via modem/ISDN for proofing and approval.

7. *Printing/publishing workflow:* Designers/clients can send PDF files to printers electronically for reproduction without worrying about missing fonts, native application software incompatibility, and/or PostScript errors.

Conclusion

Adobe Acrobat's PDF has become the information exchange standard because of its simplicity, flexibility, and universal ability. Differences in computer systems, platforms, and application software are no longer barriers to communicating and exchanging information electronically, even if the contents are visually very rich. Applications of PDF cover all areas of visual communications, from printed media to displayed media to networking media.

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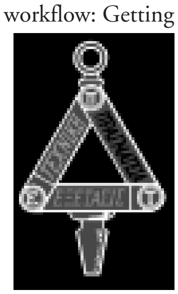

Distance Learning in Industrial Teacher Education Programs

Hassan B. Ndahi and John M. Ritz

Developments in electronic technologies are having major impacts on higher education. With the expansion of these technologies, programs listed in the *Industrial Teacher Education Directory* (Bell, 1999-2000) are beginning to experiment with alternative means of delivering courses and programs. Universities as a whole are beginning to use alternative forms of instructional delivery. Some are researching the instructional possibilities of catering to new student populations (Smith, Smith, & Boone, 2000). Others are investing in new delivery systems such as Web-based courses, one-way and two-way television, videotapes, and CD-ROM delivered courses (Okula, 1999; Pisel, 2000; Wang & Lawrence, 1996; Zirkle, 2000).

Two-way television is being used to teach classes at regional sites without having faculty travel miles to deliver the instruction. Other programs use correspondence and prerecorded video materials to deliver instruction at a distance. With the developments of the World Wide Web and its capabilities to store academic materials, some faculties are beginning to offer Web-based courses and programs. This is a natural for faculty who are experienced in teaching with various technologies.

Recently, a number of conference presentations and journal articles have been developed on the topics of distance learning and education. These scholarly works reported success stories (Russell, 2001). Because of the increased dialogue on distance learning, we undertook a study to determine the state-of-the-art of distance learning in those programs listed in the *Industrial Teacher Education Directory* (Bell, 1999-2000).

An Analysis of the Use of Distance Learning Technologies

Delivering instruction through distance learning is gaining increased use in all aspects and all levels of education. It provides additional means to reach students in different geographic locations; these may be students with individual needs, students with family and work responsibilities, and students who need to update their knowledge and skills for their current and future careers.

As a result, more and more institutions are offering distance learning courses and degree program options. This is a trend for program growth and positioning within the university setting. Although the quality of these alternative methods of delivery concern both instructors and institutions, there is not an agreement on which courses or methods of delivery are best for their programs or universities. While these issues are being debated, there is a continuing increase in the delivery of courses through distance learning methods. A survey by the U.S. Department of Education revealed that the number of distance education programs increased by 72% from 1995 to 1998, with most of the expansion coming from online offerings (Carnevale, 2000). Because of these trends, we wanted to gain information and learn from colleagues what methods of distance learning are being used to deliver distance learning courses and degree program options.

Distance Learning Institutions

Distance learning is referred to as the acquisition of knowledge and skills through mediated information and instruction, encompassing all technologies and other forms of learning at a distance (U.S. Distance Learning Association [USDLA], 2000). It uses currently available technologies to achieve two main objectives for teaching and learning: (a) providing equitable access to quality education and (b) meeting the unique learning needs and styles of individuals (Barron, 1994).

Through the use of advanced and traditional means of instructional delivery, both the instructor and student rely on electronic devices and print materials to deliver and receive instruction. The National Center for Education Statistics (1999) reported that one third of the nation's two-year and four-year postsecondary education institutions offered distance education courses and another one fifth of the institutions planned to start offering courses within the next three years.

Typical technologies used for distance learning include satellite, fiber-optic, television broadcast, compressed video, computer conferencing, audio-conferencing, radio, and videotapes. Currently, the more common technologies used for distance learning delivery are interactive satellite systems, cable television systems, microwave systems, instructional television fixed service systems, compressed television systems, and the audiographics public switched telephone networks (Baker & Dickson, 1996). These technologies enable the transmission of live one-way and two-way auditory and visual signals. Two-way audio and live video transmissions provide the teacher-student interactions that most other distance teaching technologies lack (Roach, 1998). The telecommunications industry is changing with continued improvements promised for the 21st century. Higher education faculty are taking advantage of these improvements and adapting their program delivery systems to using these technologies.

Determining Our State-of-the-Art in Distance Learning

Since faculty are active in discussing the consequences and methods of delivering courses and degree program options at a distance, we chose to survey colleges/universities to determine the extent of their use of distance learning in their instructions. Our research goals were to (a) identify which industrial teacher education institutions offer distance learning courses or degree program options; (b) identify which programs are being delivered through distance means (i.e., teacher education, industrial technology, engineering technology, etc.); (c) identify forms of distance learning technologies being used to deliver instruction; and (d) determine whether institutions allow students to take courses from other institutions through distance learning technologies and apply them toward their program degree requirements.

Population

The *Industrial Teacher Education Directory* (Bell, 1999-2000) was used to identify department chairs, program leaders, or deans responsible for academic programs in technology education, industrial education, occupational education, trade and industrial education, vocational education, vocational-technical education, industrial technology, engineering technology, and other special programs included within this directory. All institutions listed in the directory, national and international, were surveyed. This included 201 institutions, 185 national and 16 international.

Instrument

A survey instrument was developed to determine the state-of-the-art of distance learning instruction in these technical programs. It was based on the goals of this project and consisted of six questions. The study used closed and open-ended questions to gather information to achieve this purpose. Two demographic questions were directed to the individual respondents which included the institution and respondents' names.

Four other questions sought information on whether the university programs were involved with distance learning, courses or degree programs offered through distance learning technologies, technologies used for course/program delivery, and the transferability of distance courses for meeting degree requirements. These questions were based on studies that indicated the number of institutions involved in distance learning delivery (Ndahi, 1999), transfer of credits (Robertson, 1994), technology used (Okula, 1999; National Center for Education Statistics, 1999; Wang & Lawrence, 1996), and degree programs offered (Collins, Hemmeter, & Schuster, 2000).

What Was Learned

We organized and coded the responses from the open-ended questions into categories based on the pattern of responses. Frequencies and percentages were also used to analyze the data. A total of 201 institutions were surveyed including 16 from Australia, Canada, Japan, and Taiwan. A total of 91 surveys were returned, representing a 45.2% response rate. This included one follow-up to nonrespondents.

Institutions offering distance learning courses or degree. Of the 91 institutions returning surveys, 55 institutions (60.4%) offered courses or degree program options via distance learning, while 36 institutions (39.5%) did not offer distance learning courses or degree programs.

Types of degrees or programs options offered by institutions engaged in distance learning. Several degree programs and courses were offered by the responding institutions. The degrees offered were Safety Management (BS and MS), Human Resource Development,

Table 1. Degree Programs and Levels of Degrees Offered Via Distance Learning

Degree Programs	Degree Levels	No. of Institutions
1. Occup./Voc./Tech. Edu./ Trade & Ind.	AS, BS, MS	10
2. HRD/Training & Development	BS, MS, PhD	5
3. Industrial Technology	BS, MS	4
4. Safety Management	BS, MS	2
5. Workforce Education & Development	BS, MS	2
6. Engineering Technology	Not Specified	1
7. Fire Service Management & Training	BS	1
8. Human Ecology	BS	1
9. Technology Management	PhD (Consortium)	1
10. Technology Education	MS	1

Training, and Management (BS, MS, and PhD), Occupational, Vocational, and Technical or Trade and Industrial Education (AS, BS, and MS), Workforce Education and Development (BS and MS), Human Ecology (BS), Industrial Technology (BS and MS), Fire Service Management and Training (BS), Technology Education (MS), and Technology Management (PhD). Occupational, Vocational, and Technical, and Trade and Industrial Education (AS, BS, and MS) were the major degree programs offered by 10 institutions. Table 1 lists the degree programs, levels of degrees offered through distance education at institutions cited in the *Industrial Teacher Education Directory* (Bell, 1999-2000), and the number of institutions offering the degrees.

The courses taught via distance learning included Occupational Safety and Health, Basic Electricity/Electronics, AC Circuits, Electronics Technology, Industrial Management, Auto CAD, Technology Management, Multi-Media, Vocational Education Administration, Technology and Society, Computer Training, Curriculum Development, Learning Theory, Engineering Management, Technology Leadership, Industrial Safety, Advance Technology Education, and Applied Technology Training.

Types of technology used for delivery of instruction. Different types of technologies were being used to deliver distance instruction. The institutions surveyed used one or more technologies for delivery of instruction. The survey provided the following selections that were based on past findings (Okula, 1999; Pisel, 2000; Wang & Lawrence, 1996): print only, audiotape, videotape, Web-based instruction, computer-based instruction, CD-ROM, and television. Television had the following subcomponent selections: one-way video, two-way video, compressed video, or other to be filled in by the respondent. An analysis of the technologies used showed 44 institutions used Web-based delivery systems, 30 institutions used televised two-way audio

Table 2. Technology Used for Delivery

Technology Used	No. of Institutions
1. Web-based	44
2. Print/competency-based instruction packets	10
3. Videotape	9
4. CD-ROM	8
5. Audiotape	1
6. Televised instruction	45
a. Compressed video	11
b. Two-way audio and video	30
c. One-way audio and video	4

and video, and 11 institutions used compressed video. The least used technology was audiotape, used by only one institution. Table 2 shows the methods of distance learning delivery used by the institutions within these technical education programs.

Transfer of distance learning course credits. One area of concern for distance learning students was whether the credits earned via distance learning could be transferred to their home institutions to meet graduation requirements. Although cohesiveness is a major part of a degree program, all institutions had their own transfer policies. If students were within the guidelines of the home institution transfer policy and the faculty of the program allowed the transfer, then they were allowed to complete transfer courses from other institutions using distance learning techniques.

Forty-six institutions (83.6%) said that credits could be transferred into their institution, and only two institutions (3.6%) said courses could not be transferred into their programs. Seven institutions (12.7%) gave reasons such as it depends on the home institution procedures for accepting credits earned via distance learning and it was done through collaboration with institutions to which the student intended to transfer his or her credits.

Implications for the Profession

1. Institutions Involved

Of the 201 institutions listed in the *Industrial Teacher Education Directory* (Bell, 1999-2000), 91 responded to our survey, but of these, 55 institutions (28.4%) offered distance learning courses/program options to their students. Statistics for all of higher education showed 33% offering programs or degree options via distance learning. When compared to all higher education, it showed that industrial teacher education institutions were beginning to participate in distance learning, but our programs were not necessarily among the leaders of disciplines employing the technologies of modern learning.

One reason for this lower percentage might be that most programs had technical/ laboratory equipment-oriented classes as the core of their degree programs. The literature was void of writings on the delivery of technical/laboratory-based classes through distance learning techniques. However, the data gathered through this study indicated that classes such as computer-assisted drafting and electronics were currently being offered through distance learning methods.

2. Programs Being Offered

It was found that various types of programs were available from industrial teacher education institutions through distance learning systems. These included Technology Education, HRD/Training and Development, Occupational/Vocational/Trade and Industrial Education, Safety Management, Workforce Education and Development, Human Ecology, Industrial Technology, Fire Service Management and Training, and Technology Management. The program offered the most was Occupational and Technical teacher preparation, by 10 institutions, representing 18.18% of the 55 institutions that responded to the survey. We believe that this program had used alternative means of delivery for a long time, since many of the trade teachers were hired from industry and had different state requirements for teacher licensure. The print/ competency-based materials produced by the American Association for Vocational Instructional Materials had provided the foundation for licensure courses for this population of teachers.

3. Distance Learning Technologies

All forms of distance learning delivery were available within the professions of industrial teacher education studied. The instrument allowed respondents to check more than one method of distance learning delivery. As the following figures show, this, in fact, is occurring. Of the 57 institutions that offered programs through distance learning, the greatest numbers of courses/programs were delivered using televised instruction (two-way audio and video, one-way audio and video, and compressed video) by 45 institutions (81%). Forty-four institutions (80%) used Web-based delivery systems, while 18 institutions (32.7%) used CD-ROM and print/competency-based materials as delivery systems. Nine institutions (16.4%) used videotapes, and the least used delivery system was audiotapes, limited to a single institution.

4. Transfer Procedures

To determine if programs were seeking to take advantage of distance learning courses offered by other institutions, a question was posed regarding the transferability of distance learning courses into and out of their programs. Forty-six institutions (83.6%) allowed their students to enroll in and transfer distance learning credits. This is especially important to the institutions in our profession. It takes time to develop distance classes. By opening and advertising the accessibility of classes, institutions can collaborate so students can have access to complete degree requirements. For institutions involved in televised instruction, studio time may not be available for the transmission of all classes required for a complete program, and collaboration could enable higher education institutions to develop completely televised programs.

A Final Word

Although distance learning using electronic technology is not new to higher education, continued updates are needed to gauge the impact that it has on the professions cited in the *Industrial Teacher Education Directory* (Bell, 1999-2000). Of the 201 institutions surveyed, 28.4% were involved in such delivery. Further research is needed on the assets of its applicability to our professions. Research is needed to show that students are able to learn subject matter as efficiently as they do in traditional classroom/laboratory settings.

Research to explore methods of distance delivery of technical courses also needed to be undertaken. Some institutions are currently searching for methods that can be used to offer laboratory-oriented classes at a distance. Accessibility to equipment and liability issues also need to be explored.

The health care and engineering technology professions have proven that laboratory-based classes can be offered through distance means. In health care, internships are used to allow students into facilities and learn techniques from practicing health care professionals. Engineering technology has employed a procedure of offering occasional weekend classes at regional sites to enable students to complete their hands-on laboratory learning. What are the possibilities for industrial teacher education programs? This is an important issue for those programs that provide teacher licensure. Shortages of technology education and trade and industrial education teachers are nationwide. If distance learning can be used to license these teachers, it can become a winning situation for teacher preparation and teacher shortages in our public schools.

Research needs to investigate the comfort level factors associated with distance learning for both students and teachers. Teaching and learning from a distance requires adjustments for both students and teachers. What are the differences and what types of training are needed for both faculty and students (Ndahi, 1999)?

The very nature of a virtual degree using advanced electronic instructional delivery also needs to be explored. Many instructors use videotapes to support classroom instruction.

These videos are up-to-date and bring contemporary industry, business, and society into our classrooms and laboratories. The addition of this technology has been accepted by most faculty. Can electronic instruction be adapted to allow the industrial teacher education professions to create virtual degree programs where students learn more or all of their instruction from home, or provide accessibility to courses that meet their degree needs and schedules?

This research allows our professions to understand where we are in the use of distance learning for technology-based programs in higher education. We need to become imaginative as we look into the future. Technology applied in the marketplace and classrooms will continue to change. Distance learning can provide increased access to learning. Will we use the assets of distance learning to enable more people to gain teaching licenses and/or university degrees? Will we apply the teleconferencing procedures to update graduates to new technical processes or management techniques? Will we develop consortiums that share credits to enable students to obtain credentials without necessarily relying on only one university? Will distance learning lead to virtual education that will strengthen individuals' and society's access to education? Continued research needs to be undertaken to integrate distance learning technologies to the benefit of the student learning process.

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Attitudes Toward Computer-Mediated Distance Training

Sarah S. Cramer, William L. Havice, and Pamela A. Havice

Industry is demanding quality and relevant training, and is seeking new and more efficient ways to distribute training to its workers (VanBuren & Erskine, 2002). Many training programs require trainees to travel to the training location, with industry assuming much of the cost of room and board as well as transportation (Goldstein, 1997; Kasten, 1998). Training distributed at a distance can allow industry-training programs to reach more people while allowing the industry to save time and money. This study explored the attitudes of participants receiving training in industry through a means of computer-mediated distance training known as audiographics. Audiographics combines the use of voice transmission, computer networking, graphics, and data transmission through narrow-band telecommunications channels (Bradshaw & Desser, 1990; Summers, 1998).

The integration of distance education technologies provides a perfect forum for delivering training to industry. "Smart use of new training technologies will ensure that we continue to provide effective, high quality instruction and skills training while keeping costs down" (Pendaranda, 1995, p. 11). Computer-mediated distance delivery of training can allow professionals the training necessary to stay up-to-date in this ever-changing technical society without the expense of time, personal well-being, and money for travel to training locations.

According to VanBuren and Erskine (2002), total training expenditures in U.S. companies increased in 2000 and 2001 despite the slowing of economic growth and recession. Additionally, the majority of U.S. companies expect their training expenditures to increase rather than decrease in 2002. Furthermore, the use of outside training providers such as private consultants and educational institutions will increase (VanBuren & Erskine, 2002). Corporations can utilize distance education technology to distribute cost-effective and quality training to their employees. Because there is a need for constant upgrading and retraining knowledgeable employees (Kiplinger & Kiplinger, 1996), business will increase its role in education and training (VanBuren & Erskine, 2002). Therefore, as the cost of training continues to rise, industry will require more cost effective ways to deliver instruction.

Distance Education and Distance Training

Forms of communication such as audio-, video-, and computer-conferencing have helped to make distance learning sophisticated, exciting, and efficient for the distance learner who is not actually in the physical presence of his or her trainer while learning. With these forms of communication the learner can be in the next building, at home, or in a place located hundreds of miles away (Duguet, 1995) and still access the training.

What is the difference between distance education and distance training? Devlin (1993) described the difference between distance education and distance training as follows: Distance education is typically student centered. Learners are encouraged and facilitated to pursue their own needs and preferences within the subject matter under study. Much of the literature defines distance education as learning that takes place when time and space separate student and teacher. Distance education is defined by the National Center for Education Statistics (1998) as "education or training courses delivered to remote (off-campus) locations via audio, video, or computer technologies" (p. 1). Correspondence courses are an example of distance education that has been available for many years.

Distance training, conversely, is driven and controlled principally by the needs of the organization. These needs, expressed simply, are to have effective, generally task-oriented skills acquired by trainees in the most cost-efficient manner possible. The role of defining the student's learning and competence needs is assumed by the organization (Devlin, 1993). Training involves a narrow focus aimed at specific skills and competencies. Typically, training goals are those of the organization rather than the personal goals of the individual (Chute, Thompson, & Hancock, 1999).

Distance Delivery Methods and Media

Of the two modes for delivering distance training, synchronous instruction is when learners and instructors participate in instruction simultaneously and in "real time" (Steiner, 1995). Examples of synchronous instruction include interactive television, audio-conferencing, audiographics, teleconferencing, satellite conferencing, interactive relay chat (IRC), and multi-user object oriented (MOO).

Asynchronous instruction does not require simultaneous participation. Chute et al. (1999) defined asynchronous as "interaction between two or more people that is time-delayed, that is, separated by minutes, hours, or even days" (p. 219). Examples of the asynchronous delivery mode for delivering education at a distance include e-mail, videotaped courses, correspondence courses, and World Wide Web-based courses (Steiner, 1995).

Interaction among learners, between the learners and the content, and between the learners and the instructor is important to the learning process. Moore and Kearsley (1996) described three types of interaction to be included in a distance-training program: learner-content interaction, learner-instructor interaction, and learner-learner interaction. They stated that it is "most desirable for distance educators to use all three kinds of interaction" (p. 132). Hillman, Willis, and Gunawardena (1994) identified a fourth type of interaction not mentioned by Moore and Kearsley. Learner-interface interaction is "a process of manipulating tools to accomplish a task" (Hillman et al., 1994, p. 34). An appreciation for this type of interaction has become necessary because of the increasing use of high-technology communication systems in distance education. In other words, "the inability to interact successfully with the technology will inhibit his or her involvement in the educational transaction" (Hillman et al., 1994, p. 34).

Audiographics uses existing computer networks and telephone lines to deliver education and training to anyone on the computer network. This method of delivery is seen as more cost effective and practical than expensive videoconferencing. Freeman (1999) found that "the comparative costs associated with delivering graduate instruction via audiographics were calculated at less than 14% of the cost of satellite based instructional television" (p. iii).

Microsoft® NetMeeting, a commercial software application that can be used to deliver training by audiographics, includes audio, video, and whiteboard capabilities (Summers, 1998). NetMeeting allows instructors and students to login synchronously. The trainer can show a Microsoft® PowerPoint slide presentation from his or her computer to the class who can view the presentation whether or not they have the PowerPoint application available. The quality of the audio capabilities of NetMeeting can be problematic and is probably not adequate for use in all training situations (Summers, 1998). A conference call over a standard telephone line can be substituted for the audio capabilities of NetMeeting, successfully providing quality audio to all participants at multiple locations.

Attitudes

The majority of studies conducted on distance education and training compared to traditional education and training have found that there is no significant difference in achievement among learners (Freeman, 1999; Havice, 1999; McGreal, 1994; Ryan, 1996). The technology used for delivering the course is not the most important factor, but rather well-designed courses that are well delivered and conducted are important (Moore & Kearsley, 1996; Russell, 1999). Havice (1999) concluded in his study that "it is the method not the medium that influences the psychological processes that allow learning to take place" (p. 54).

There have only been a handful of studies comparing audiographics to traditional learning environments. Freeman (1999) found "no significant difference in the learning performance of any of the groups as measured by the cumulative course scores" (p. ii). Two other studies comparing traditional with audiographics delivery of courses also found no significant difference in the success of the students (McGreal, 1994; Ryan, 1996). Furthermore, Wisher and Curnow (1999) concluded that there is no training advantage to having a video image of the instructor.

Extensive research in the area of student attitudes towards televised courses has been done by Biner and his colleagues (Biner, 1993; Biner & Dean, 1995; Biner, Welsh, Barone, Summers, & Dean, 1997). They have suggested that attitude is as important as achievement to determine the effectiveness of a distance education program, and they express the importance for an ongoing plan of attitudinal assessment. The conclusions of Biner et al. are further supported by Havice (1999), who noted that people pay attention to what they enjoy and that "information is retained when it is consistent with attitude and disregarded when it is in conflict with attitude" (p. 51). Therefore, high learner satisfaction with a distance training program can mean lower dropout rates, greater numbers of referrals to bring other learners into future programs, and higher levels of learner motivation and commitment to the program.

What We Did

The purpose of this study was to explore the attitudes of trainees who attended a customer service representative workshop through the use of audiographics in one of two locations. An experimental group (n = 20) received the graphic presentation through the Internet and Microsoft® NetMeeting projected onto a screen from one computer. The experimental group also received the audio through a standard telephone line and a speakerphone. The control group (n = 20) received on-site training face-to-face with the instructor. There were 20 participants in each group for a total of 40 subjects (N = 40) in the sample.

Research Question

The research question asked if there was a significant difference in attitude between those participants instructed through traditional training and those participants instructed through audiographics in a customer service workshop. A revised version of the Telecourse Evaluation Questionnaire (TEQ; Biner, 1993) was administered at the conclusion of the workshop to measure the participants' attitudes towards training delivered at a distance through audiographics.

The TEQ contains four sections. Section 1 contains 14 questions about instruction and instructor characteristics. Section 2 looks at technological characteristics with 7 questions, while Section 3 reviews course management and coordination with 5 questions. Section 4 asks for general course and demographic information. Each question 1 through 27 required a response on a 5-point Likert-type scale in which 1 = *very poor,* 2 = *poor,* 3 = *average,* 4 = *good,* and 5 = *very good*.

What We Learned

Technology provides a way to meet training needs by delivering low-cost, high-quality instruction. Several aspects of teletraining are very important, including upfront preparation of the program, along with allotting sufficient time and money for planning, design, materials preparation, and preproduction. Solid preparation, added to the right technology, results in training that is both instructionally sound and cost effective. No technology by itself will solve a problem or meet a training need. Training will not be effective, no matter what technology is used, without good instructional design (Pendaranda, 1995).

The resulting means for each question were addressed. For every question but one, the overall means and the means for each group were above the average score of 3. The mean score for the question concerning the audio quality from the control group was 2.47, while the mean score for the experimental group was 2.7, both below the average score of 3. Although high-quality speakerphones were used at each location to facilitate quality audio between the two groups, both groups rated the audio from participants at the other location as poor to average. All other aspects of the training were rated as above average to very good. Therefore, it can be inferred that overall, participants had very positive attitudes toward the delivery of the workshop.

On each question of the revised TEQ, t tests for independent means were performed (see Table 1). For every question, the critical value was greater than the observed value meaning. Therefore, the attitudes were the same for the control and experimental groups.

It was determined that the location of the speakerphones in the training room, the natural voices of the participants, and the other distractions in the room can affect the quality of the audio between training locations. It is recommended that the participants be seated around and close to the speakerphone and speakerphone remote antennae. Chute et al. (1999) wrote that audiographic equipment dictates the need for a conference table large enough for 14 people to sit around comfortably with room around the perimeter for additional chairs and equipment. Participants should also be encouraged to speak up and not mumble as they communicate with the other location.

Table 1. Means and *t* Values for Participant Attitudes

Question	Control	Experimental	Total	*t* value
1. Clarity of communication	4.20	4.33	4.26	0.60
2. Time graphics shown	3.70	4.10	3.90	0.15
3. Degree graphics helped	3.95	3.80	3.88	0.57
4. Quality of graphics	4.20	3.95	4.08	0.26
5. Help of instructor techniques	4.25	4.00	4.13	0.30
6. No environmental distractions	4.10	4.05	4.08	0.87
7. Extent you felt a part of the class	4.35	4.50	4.43	0.53
8. Instructor's communication	4.45	4.35	4.40	0.68
9. Instructor's class prep and organization	4.20	4.45	4.33	0.31
10. Instructor's enthusiasm	4.60	4.55	4.58	0.81
11. Instructor's teaching ability	4.50	4.45	4.48	0.82
12. Class participation encouraged	3.85	4.00	3.93	0.60
13. Instructor's professional behavior	4.70	4.55	4.63	0.43
14. Overall, the instructor was…	4.50	4.40	4.45	0.63
15. Quality of screen picture	4.30	3.50	3.90	0.01
16. Quality of instructor audio	4.55	3.70	4.13	0.00
17. Adequacy of screen size	4.50	4.25	4.38	0.27
18. Quality of participant audio	2.47	2.70	2.60	0.51
19. Brevity of talkback delay	3.77	4.21	4.00	0.05
20. Promptness of instructor answers	3.71	4.26	4.00	0.03
21. Confidence of no interruptions	3.37	3.85	3.62	0.12
22. Reaction of material exchange	3.80	4.10	3.95	0.27
23. Conscientiousness of site coordinator	4.05	4.45	4.25	0.06
24. Accessibility of site coordinator	4.11	4.60	4.36	0.01
25. Someone able to operate computer	3.75	4.55	4.15	0.00
26. Registration procedures	4.00	4.39	4.18	0.15
27. Overall, the course was…	4.05	4.15	4.10	0.75

Overall Participant Analysis of the Workshop

Overall, participants rated the workshop as above average to good (see Table 2). The majority of participants rated this workshop as about the same to a little better than conventional workshops they had taken. Thirty-six participants ($N = 40$) indicated that they would take another workshop delivered like this one. Four participants in the experimental group ($n = 20$) indicated that they would rather see the instructor.

Thirty-four of the participants ($N = 40$) indicated that they would recommend this workshop, while three participants at each location indicated that they would not recommend this workshop. Those participants who would not recommend this workshop gave the course an overall rating of average to poor and said that this course was the same as, worse, or much worse when compared to conventional workshops. Participants in the experimental group who would not recommend this workshop cited lack of visual contact with the instructor as a disadvantage of distance training and the cause for difficulty in concentration. They also recommended videoconferencing as an alternative. None of these participants would enroll in another workshop delivered like this one. The control group participants who would not recommend this workshop cited poor audio quality from the remote participants, less interactivity, and problems with the phone and computer as disadvantages of distance training.

Table 2. Overall Analysis from Participants

General Workshop Questions	Control	Experimental	Total
Overall, the course was…*	Good (4.05)	Good (4.15)	Good (4.1)
Compared to conventional courses, this course:*	Same as to better (3.6)	Same as (3.1)	Same as (3.35)
Would you enroll in another workshop delivered like this one?	Yes: 19**	Yes: 16 No: 4	Yes: 16 No: 4
Would you recommend this workshop to a friend?	Yes: 16 No: 4	Yes: 17 No: 3	Yes: 16 No: 4
Would you still have been able to attend this workshop if it had not been offered through distance training? (Experimental only)		Yes: 5 No: 15	
Including this course, how many courses taught at a distance have you taken to date?	1.35	1.25	1.3

* Scale 1 to 5.

** One person did not respond to this question.

Two of these control group participants indicated that they would enroll in another workshop delivered like this one, while the third did not answer the question. Fifteen of the participants in the experimental group ($n = 20$) indicated that they would not have been able to attend the workshop if they had had to travel.

What It Means

Findings from this study indicate that well-designed workshops, which foster positive attitudes among participants, can be delivered effectively through distance media. This supports studies done by Moore and Kearsley (1996) and Russell (1999). Using cost-efficient software, such as Microsoft® NetMeeting, in combination with high-quality instruction ensures that effective, low-cost instruction and skills training can be a reality. Audiographics is just one of the many ways that distance learning can touch the lives of many learners who because of time, money, and/or other commitments cannot devote the resources to attending on-site workshops, courses, or seminars.

Further studies would be useful in studying several facets of distance learning. These could include the following issues: rate of retention for participants in distance training, determining the effectiveness of audiographics versus video-conferencing, allowing a second remote site to see the instructor during the workshop, determining the effectiveness of different presentation methods, determining the relationship between prior exposure to distance training and attitudes towards computer-mediated distance training, determining the effectiveness of delivering the training directly to the workplace, and determining the effectiveness of a multiweek training course delivered at a distance through audiographics.

*For more information about the Telecourse Evaluation Questionnaire (TEQ), please contact Sally Cramer, EdD, at *sslcramer@earthlink.net.*

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IDEAS

Mapping Dimensions of Technological Literacy to the Content Standards

Larry Hatch

The *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000) provides the profession with a blueprint to address an important public need. The public, however, is often not inclined to read a 200+ page volume or even an executive summary. When the United Kingdom's (UK) National Curriculum for Design and Technology was introduced, Gordon (1992) developed and used a graphic or content map illustrating the major elements of the plan in a single diagram. For visual learners a content map can concisely link content components in an organized fashion. With a tightening school curriculum, communicating clearly and concisely is vital.

The content standards must not be viewed as ever-larger doses of knowledge to be injected into children as displayed in this figure. Mere inoculations of more information about technology cannot hope to provide the transferable skills for tomorrow's citizens. Rather the purpose (i.e., technological literacy) and the content standards must be clearly linked in a manner that communicates with the audience. The relevance, realism, and richness of the standards can be illustrated through a content map. The content standards are more than just big needles of information; they reflect the important and realistic goal of achieving the civic, practical, and cultural dimensions of technological literacy.

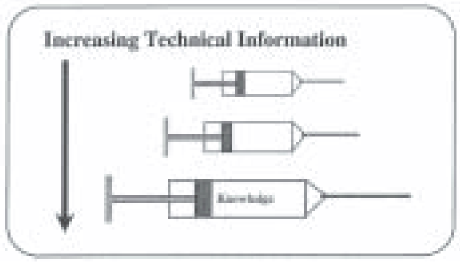

Figure 1. Injection curriculum theory.

These dimensions are never directly referred to in the content standards document but nonetheless underpin the rationale. Aspects of the dimensions are even imbedded in the content standard's definition of technological literacy, which is described as "the ability to use, manage, understand, and access technology" (ITEA, 2000, p. 242).

A definition of technological literacy that does include these dimensions appears in the Council on Technology Teacher Education 40th Yearbook (Dyrenfurth, Hatch, Jones, & Kozak, 1991):

> Technological literacy is a multi-dimensional term that necessarily includes the ability to use technology (**practical dimension**), the ability to understand the issues raised by our use of technology (**civic dimension**), and the appreciation for the significance of technology (**cultural dimension**). (p. 7)

The civic, practical, and cultural dimensions describe the citizen who is informed, productive, and cultured. Graphically these dimensions can be used to map out the relationship to the content standards.

The practical dimension is central to technology education and represents the heritage of this curriculum area. This dimension resides graphically in the core of the content map.

The practical dimension in the diagram reflects the content standards 8–13. The term *technological method* coined by Savage and Sterry (1990) is used as an appropriate label for this dimension. The technological method is the mechanism used to engage students in working with real problems; this is the focal point, the very heart of the unique contribution technology education offers. The term *capability* is used here to replace the multiple use of the term *ability* within the benchmarks.

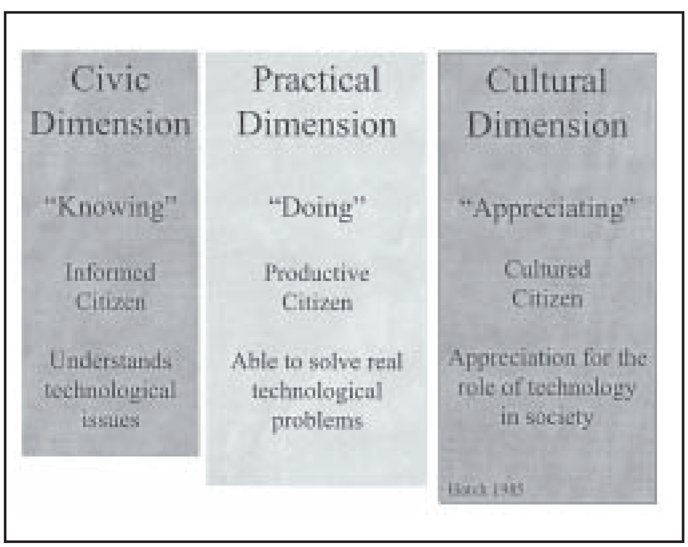

Figure 2. Dimensions of technological literacy.

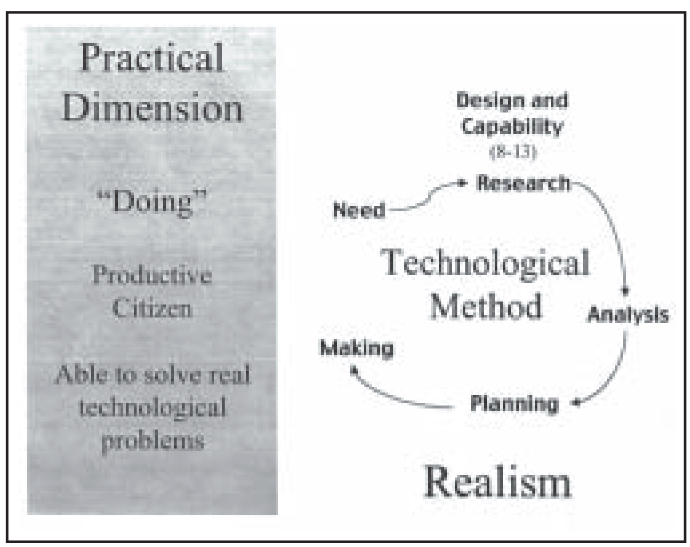

Figure 3. Practical dimension.

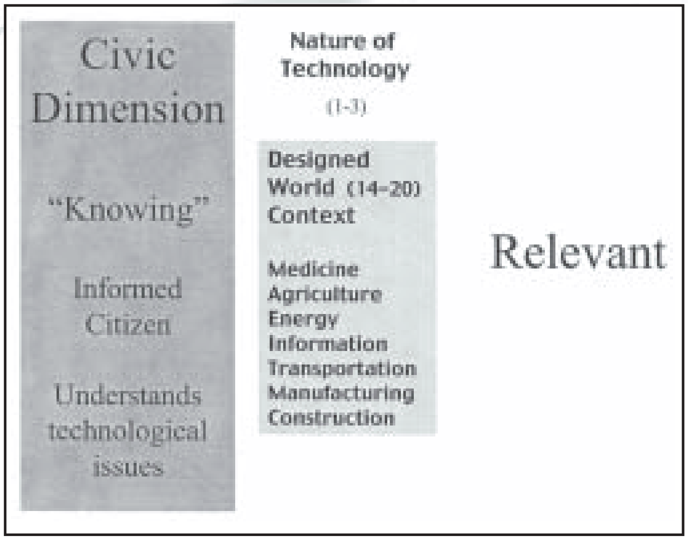

Figure 4. Civic dimension.

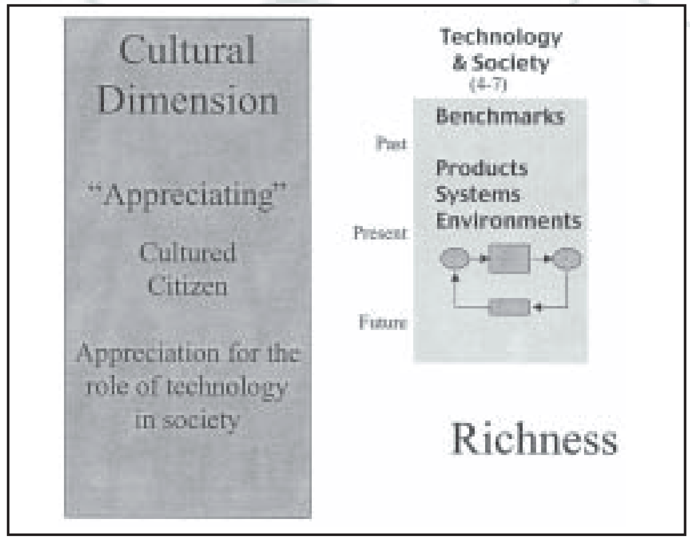

Figure 5. Cultural dimension.

Content standards 1–3 and 14–20 reflect the civic dimension of technological literacy. An understanding of the **Nature of Technology** and the **Context of the Designed World** are the building blocks needed for an informed citizen. This dimension brings relevance to the curriculum and provides a starting point to engage students in the technological method (practical). This list of what use to be course titles now becomes a reservoir for contextual real world problems.

Therefore, the knowing and doing elements are interactive to make learning both relevant and real. The technological method provides transferable skills that equip students to better understand the technological issues and challenges in additional contexts. What is missing in this graphic is the cultural dimension of technological literacy.

The cultural dimension challenges the learner to step back and examine the artifacts of the created world in light of their impact on society. Most technological advances take the form of a product, system, or environment. In fact, almost every student project can be classified along these lines. Analysis of products, systems, and environments over time can provide a sense of a person's technological heritage and the role technology will play in his or her life. This brings richness to the technology education curriculum.

This content map can be used to explain both the *what* and the *why* of

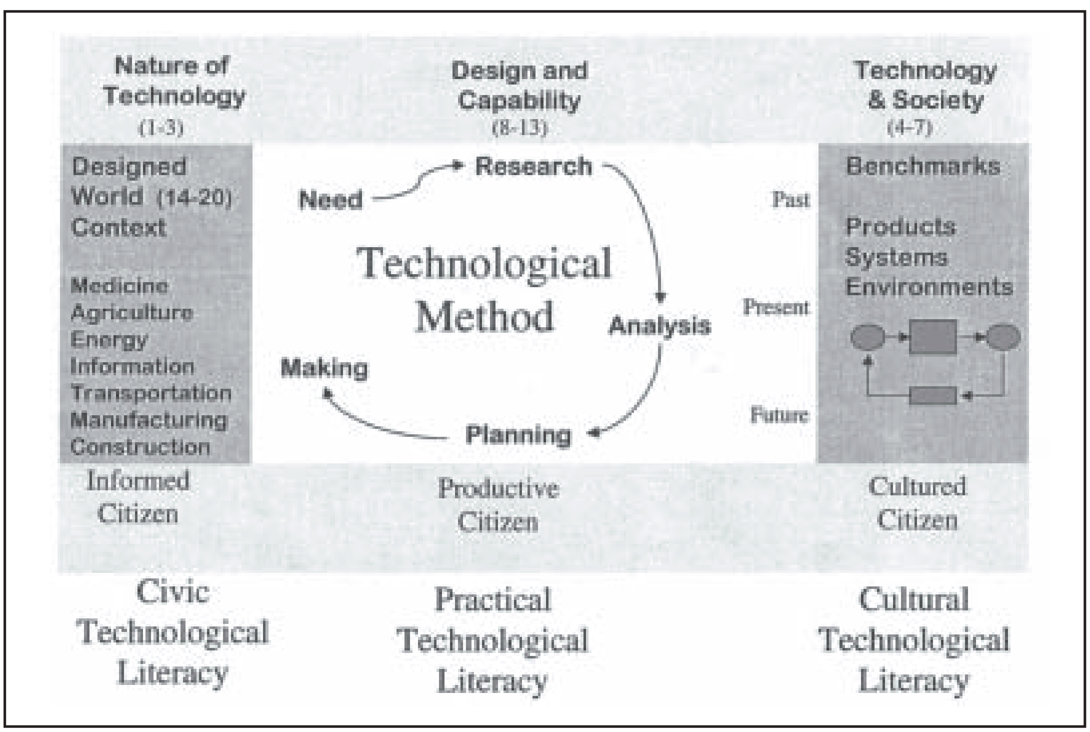

Figure 5. Content map for technological literacy.

the content standards. The map can tell us where we are going and how we are getting there. It links the content standards to the outcomes of technological literacy. It has been adapted here to reflect the content standards and dimensions of technological literacy. It is important to consider this or other content maps that provide the public with a concise graphic of both the rational and content standards for technological literacy.

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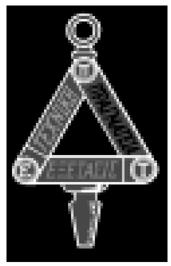

A New High School Graduation Experience Requires Increased Staff Computer Literacy

Addie M. Johnson

More than ever before, teachers are being required to gain more refined technical knowledge in computer-based literacy. New academic and technology standards are being initiated as exemplified by their introduction into Pennsylvania's high school curriculum.

In addition, this state has instituted a culminating project for graduating seniors as a basis for awarding student merit diplomas rather than merely certificates of school attendance. Since many high school students either take computer literacy courses or are self-taught through their own exploration and creativity, they have gained a broad range of technical skills beyond that of most of their regular classroom teachers. Although there has been an increase in the number of computer-literate teachers in Pennsylvania, their population is still inadequate to effectively guide student technology-based graduation projects. While students enjoy exploring the latest technology, many veteran teachers avoid experimenting beyond basic word processing and e-mail. Students who do need assistance must either fend for themselves or learn from their peers in utilizing PowerPoint and other applications to create acceptable senior projects. Therefore, professional development focused on increasing teacher competency to guide students as they develop creative, well-designed, and aesthetically acceptable projects needs to become a local school district priority.

Computer literacy training involves numerous unresolved issues between school district administrators and teachers. One primary issue resides in school district financial capability to offer updated training in technology skills; this is juxtaposed against the lack of teacher desire to gain essential expertise through professional development programs. Many school boards across the country generally allot a little over 1% of a school district's budget for professional development. Decisions regarding time and money allocation are often determined for specific school district curricular goals mandated by state and/or federal guidelines that diminishes the focus on providing professional development for faculty, staff, and administrators.

Although issues of "funding" and "faculty participation" in technical training will be resolved over time, there is a widespread movement toward improving the technology preparation of teachers. The National Board for Professional Teaching Standards strongly encourages states to include technology as a requirement for teacher licensing. During the Clinton administration, the U.S. Department of Education created the office of Preparing Tomorrow's Teachers to Use Technology with the responsibility of developing a national training initiative. Dr. Thomas Carroll, the first appointed program director, stated that

> the power of technology for student learning doesn't come from the presence

> of classroom computers. The real power of technology in education will come when teachers have been trained well and have captured the potential of technology themselves. Teachers should model the behavior students are expected to learn. (Seeger, 1999)

Many teachers currently entering the field are more technically competent; it is hoped that their enthusiasm will motivate and assist veteran colleagues in becoming computer literate.

In Pennsylvania, newly appointed teachers are mandated to complete certification requirements by acquiring an additional 24 graduate school credits; most novices do so in conjunction with work for the master's degree. Although there are no state requirements for technology courses as part of teacher licensing, the availability of university technology course electives for teacher permanent certification becomes one commendable pathway to enhance teacher technical skill.

Pennsylvania's technology standards for student instruction and assessment were reviewed by the Department of Education for approval and implementation during the year 2000. The endorsement of technology standards by the state represented another mechanism necessitating school districts to hire more computer technology coordinators and provide more training for K–12 staff.

The following section provides a glimpse of the type of program requirements for Pennsylvania's student graduation project, thereby offering a perspective on the rationale for more widespread teacher computer literacy training.

Graduation Project Program Descriptors: A Perspective

The philosophical background of the "project" approach is one advocated by Sizer (1992) in his theoretical premise of the nine principles of learning fostered in "The Coalition of Essential Schools" program. Sizer believed firmly in offering students alternative assessment formats such as exhibitions and projects where student knowledge can be displayed and assessed better than using traditional means. His thesis is supported by Gardener's (1993) work, which offers students opportunities to learn according to their dominant intelligence and to demonstrate that knowledge using relevant assessment formats.

In requiring a culminating project for graduation, Pennsylvania Department of Education curriculum personnel and state lawmakers apparently believe that student demonstration of an area of knowledge, utilizing projects and exhibitions, represents a valid form of alternative assessment. In addition, a by-product of this mandate perhaps will increase and maintain student interest in senior high course offerings and constitute one facet of a preventative dropout program. In keeping with a gradual national trend toward terminal school year demonstrations of student knowledge, using the exhibition style as a "gatekeeper" for obtaining a high school diploma of merit serves as an acceptable accountability factor in satisfying future employers and a critical taxpaying public.

Graduation Project Components

The Pennsylvania state guidelines for graduation require "course completion and grades, completion of a culminating project, and results of (successful) local (and state) assessments aligned with the academic standards" for a diploma with a state seal of Proficiency or Distinction (Pennsylvania Code, Title 22). Pennsylvania Department of Education guidelines assert that Graduation Project procedures are to be a part of each school district's strategic plan (a document submitted periodically to the Pennsylvania Department of Education) by 2003. Although guidelines are vague, they provide individual districts with some degree of latitude for interpretation as exemplified in the statement mandating this initiative:

> The purpose of the culminating project is to assure that students are able to apply, analyze, synthesize and evaluate information and communicate significant knowledge and understanding. (Pennsylvania Code 4.24, Title 22, State Board of Education)

Many senior high school teachers view this mandate as an opportunity to facilitate student enrollment retention through graduation, motivate student completion of course requirements in anticipation of a diploma of proficiency or distinction, and encourage student responsibility in being better prepared for either postsecondary education or the workplace. Aligned with this procedure is a small but developing plan among Chamber of Commerce groups to require diplomas of merit for entry-level positions in local labor markets, thus granting more value to graduating senior achievement. Culminating projects would demonstrate skills representative of student achievement throughout a 12-year educational experience. For purposes of definition, graduation projects represent culminating reports consisting of research topics or work-related experiences conducted over an agreed upon period of time, in a student-selected field of interest, to be completed within school procedures and guidelines for reporting and presentation.

Project topic selection may be made from a wide variety of available sources. Many high schools encourage students to become actively involved in a graduation project that may be community service oriented or bear some relationship to a student's future goals; however, the primary requirements are that it is student-selected and represents a high degree of student interest. Representative project topics may consist of computer repair apprenticeships, veterinary medicine experiences, expanded science fair projects, historical meteorology, auto mechanics computerization, or design of an interactive visual basic program for mathematics remediation, etc. Resources for project activities exist both within and outside of schools; for example, library research (both actual and online), interviews with experts in a field, volunteer activities in areas of interest, community civic service, research/work experiences in health organizations and agencies, local businesses and universities, computer labs, etc.

Since many senior high students are either currently enrolled in computer courses or self-taught, students appear to enjoy creating presentations utilizing different types of technology. Projects may range from sound-videos to more hi-tech productions. In many senior high schools, students having mastered computer courses in Microsoft Office and Hyperstudio are capable of creating presentations utilizing word processing, spreadsheet, multimedia, video, CD-ROM, digital cameras, and pertinent information from Internet sites. What's missing in this picture is the capability of regular subject discipline teachers to provide the guidance essential to the development of an organized, aesthetically viable project.

There is the argument that since many senior high students possess an understanding of a variety of computer applications, why is there the necessity for subject area teachers to understand these technologies? The answer to this query resides primarily in the fact that students may select a graduation project advisor from any subject discipline relevant to their project topic regardless of teacher proficiency in computer technology. Although some senior high schools retain a technology coordinator, normal position responsibilities would not allow sufficient time for adequate student project assistance. Student population size, another constraining factor, would limit faculty access and preclude quality research and presentation formats. Additionally, there is the question of whether faculty who develop rubrics to judge graduation projects and student oral presentations will do so considering the type of medium students may select to utilize in project development.

According to the design offered by Schell and Hornberger (2000) in their Graduation Project Booklet, students are scored on project content, organization, and delivery in addition to submittal of some form of written research work. Therefore, the prospective auto mechanic may create an audio/video presentation but is also expected to submit a written research paper of the length agreed upon with

Table 1. Sample of Topics Normally Covered in Graduation Project Booklets

Topic	Subtopic
Senior High Faculty Roles	Graduation Project Coordinator (entire school) Research Paper Coordinator Technical Assistants (Professional/Paraprofessionals) Graduation Project Advisors
Project Timeline	From Sophomore to Senior Year From May of Junior Year to March of Senior Year
Project Procedures	Project Topic Selection Project Advisor Selection Graduation Project Proposal Form Advisor Approval Form/Course Credit Monthly Progress Reports Research Paper/Oral Presentation Schedule
Graduation Project Requirements	Academic/Honors/Grading Procedures Minimum/Maximum Hour Allotments for Research Paper & Oral Presentation Preparation
Guidelines	Faculty/Student Responsibilities Sample Logs and Formats
Project Topics	Project Resources
Grading Scales	Research Paper (Content/Organization/Conventions) Rubrics for Oral Presentation Presentation Skills/Content/Audience Interaction
Rubric Range	(6 domains) Superior/Above Average/Competent/ Marginally Competent/Not Competent/Seriously Flawed

Note: From Schuylkill Valley School District Graduation Project Information Manual (pp. 5–20) by S. Schell and D. Hornberger, 1998, Schuylkill Valley, PA: Schuylkill Valley School District.

his or her selected graduation project advisor. Sample criteria for honors students mandate reports with a required number of citations from literary sources. Students opting for multimedia presentations likewise are required to follow similar guidelines, but adaptations of these models will vary according to individual school decisions. However, the main point is that teachers need a more substantial knowledge of computer applications to provide the guidance essential for those students who elect to engage in computer-based projects.

A Framework for Pennsylvania Graduation Project Requirements

A brief overview of sample guidelines based on a review of several formats of graduation projects representative of different senior high schools in Pennsylvania reveals similar patterns of project requirements. First, many districts introduce the project in the student's sophomore year to provide sufficient time for student exploration of topics, selection of project advisor, decisions regarding methods of presentation including use of varied technologies, and identification of available resources. Second, a booklet, devised by a faculty committee consisting of instructions, procedures, sample logs, and requirements, is disseminated to teachers, students, and parents. A representative sample of topics normally covered in graduation project booklets is outlined in Table 1.

As demonstrated in this article, there is a need for teachers, especially those serving senior high school students, to acquire appropriate computer literacy skills and knowledge of content-specific curriculum software as well as learning to guide students in utilizing appropriate search engines to obtain worthwhile information from the wealth of knowledge available on the Internet. The rapid pace of technological progress at the onset of the 21st century represents an opportunity to radically transform educational practice. Innovative curriculum and pedagogical changes are required to capitalize on this opportunity. It is hoped that school districts and teacher groups will join forces to achieve competency in technological literacy for this represents essential survival skills in our century.

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Business Education Leaders Compare E-mail and Regular Mail Survey Research

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As we step into the new century and adapt to many new technological advancements, researchers are looking to technology to increase the effectiveness of the data collection process. Indeed, researchers have touted the notion that e-mail will be the preferred survey delivery method in the 21st century (e.g., Bachmann, Elfrink, & Vazzana, 1996). Several writers have outlined the strengths of e-mail technology as a survey delivery method (e.g., Oppermann, 1995; Thach, 1995; Truell, 1997). As a technology, e-mail offers several strengths as a survey delivery method, chiefly delivery/response speed, lower costs, worldwide geographic coverage, favorable response rates, ease of editing, openness of responses, environmental correctness, semi-interactive nature, and a variety of response options (Truell, 1997). Despite the strengths associated with using e-mail technology for survey delivery, it behooves researchers to compare the use of this technology with an established method such as postal mail prior to making decisions on its appropriateness for use. Indeed, Truell (1997) noted that the difficulties of using e-mail technology for survey distribution will likely be reduced as researchers conduct more e-mail research and establish a protocol.

Researchers who have used e-mail technology for survey delivery report mixed results. Investigators, in the majority of studies, have reported higher response rates for postal mail than for e-mail delivered surveys (e.g., Bachmann et al., 1996; Kittleson, 1995; Mavis & Brocato, 1998; Tse, 1998). Kawasaki and Raven (1995) reported mixed results depending on the participants involved, while Parker (1992) indicated a higher return rate for e-mail than for postal mail surveys. In addition to response rates, e-mail and postal mail surveys have been assessed regarding response speed and response quality. In all cases, email surveys were distributed and returned faster than postal mail surveys (e.g., Bachmann et al., 1996; Mavis & Brocato, 1998; Oppermann, 1995). Researchers have reported similar response quality for the two methods (Mavis & Brocato, 1998; Mehta & Sivadas, 1995; Tse, 1998).

The literature contains relatively few studies that compare the effectiveness of email technology with postal mail as a survey delivery method (i.e., Bachmann et al., 1996; Kiesler & Sproull, 1986; Kittleson, 1995; Marvis & Brocato, 1998; Parker, 1992; Rafaeli, 1986; Schuldt & Totten, 1994; Tse, 1998). In fact, "the potential for collecting data through e-mail is relatively unknown in the social sciences" (Kittleson, 1995, p. 27). Mehta and Sivadas (1995) stated that "very few studies have attempted to evaluate newer information technologies as a way of collecting data" (p. 429). Many of "the earliest studies of e-mail surveys were restricted to populations sampled from within a single company or university" (Bachmann et al., 1996, p. 31). Consequently, this research builds upon the previous studies that have examined the feasibility of e-mail as a survey delivery method by assessing its effectiveness for use with leaders in the field of business education and by incorporating recommended design changes put forward by earlier researcher into this study. Results of this study are expected to provide insight as to the potential of using e-mail as a survey delivery method in a setting involving leaders in the field of business education.

The Why and How of the Study

We worked to examine the response rate, response speed, and response quality of e-mail and postal mail surveys distributed to business education leaders. Specifically, we wanted to determine (a) the response rate of e-mail and postal mail surveys distributed to leaders in the field of business education, (b) the response speed of e-mail and postal mail surveys, and (c) the difference in the response quality of e-mail and postal mail surveys. Two hundred fifty-six leaders in the field of business education included on the Business Education Professional Leadership Roster that appeared in the December 1998 issue of *Business Education Forum* with working e-mail addresses served as study participants. A 10-question dummy survey containing five closed-ended and five open-ended questions was used to collect data. The same questions were included in both versions of the survey with the e-mail version consisting of a slightly different format to avoid any potential word wrap viewing problems. Recipients of the e-mail version of the survey were also provided additional options of returning completed surveys by regular mail or fax because of the flexibility these options reportedly provide respondents (Parker, 1992; Truell, 1997). The 256 participants were randomly assigned to one of two groups. One group was e-mailed the survey while the other group was mailed the paper version of the survey. Three weeks following the initial distribution, a follow-up e-mail or postal mail survey was sent to nonrespondents. Data collection ended on day 56 of the study.

What We Learned

Using the Statistical Package for Social Sciences (SPSS), we used descriptive statistics of means and percentages. We also used tests to determine differences on response speed and response quality. Tests of

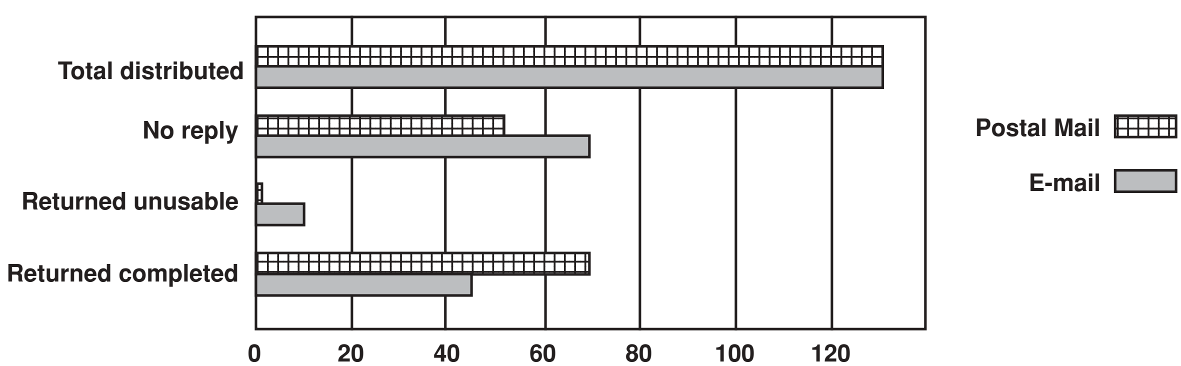

Figure 1. Response rate for e-mail and postal mail surveys.

significance were set at alpha = .05.

For Objective 1 (Response Rate): Of the 128 e-mail surveys distributed, 59 (46%) were returned to the researchers in one form or another. Specifically, 34 (26.6%) surveys were completed and returned via e-mail, 13 (10.1%) were completed and returned via postal mail, and 12 (9.4%) were returned via e-mail but were blank and deemed unusable. The total number of usable e-mail responses was 47 (36.7%). Of the 128 surveys distributed via postal mail, 73 (57%) were completed and returned. All postal mail surveys returned provided usable data. Figure 1 provides a breakdown of e-mail and postal mail survey response rates.

For Objective 2 (Response Speed): It took, on average, 12.5 days over the two rounds of instrument distribution for an email survey to be returned. By contrast, it took, on average, 24.2 days over the two rounds of instrument distribution for a postal mail survey to be returned. Results of the data analysis, $t(118) = 5.42$, $p < 0.00$, show a statistically significant difference in the response speed of e-mail and postal mail distributed surveys. In being returned to the researchers, email surveys were significantly faster than postal mail surveys.

For Objective 3 (Response Quality): On average, participants responding to the e-mail survey completed 20.9 of the 35 possible responses. By contrast, respondents filling out the postal mail survey completed, on average, 19.4 of the possible 35 responses. Results of the data analysis, $t(118) = -0.99$, $p < 0.32$, show no statistically significant difference in response quality of e-mail and postal mail distributed surveys.

What It Means

The postal mail distribution method had a higher return rate than the e-mail distribution method. This is consistent with earlier research comparing e-mail surveys and postal mail surveys. Response speed of e-mail surveys was significantly faster when compared to the response speed of postal mail surveys. These results are also consistent with the findings of earlier researchers. The response quality of e-mail distributed surveys and postal mail surveys was similar. This, too, is consistent with the findings of earlier researchers.

Recommendations

1. A replication of this study should be undertaken using a probability sample. Many of the earlier studies, including this one, have not been able to generalize because of the nonprobability nature of participant selection. A replication of this study using a probability sample would enhance the findings of any future study comparing the response rate, speed, and quality of e-mail and postal mail surveys.
2. A study comparing the response rate, response speed, and response quality of surveys presented on the Internet with postal mail surveys should be conducted. Many businesses and organizations post surveys on the Internet as a method of collecting data from their various publics. Participants may be more likely to respond to a survey presented on the Internet than they are to a survey presented by e-mail simply because of format and familiarity. E-mail messages could be sent to participants with a link to the survey site embedded in the text for ease of locating and responding to the survey.

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