

The Journal of Technology Studies

On-line Edition

Volume XXX, Number 1.

Winter 2004

**Promoting Excellence in Preparation
and Excellence in Practice**



A refereed publication of

Epsilon Pi Tau

The International Honor Society for Professions in Technology

The Journal of Technology Studies

A refereed publication of *Epsilon Pi Tau* The International Honor Society for Professions in Technology.

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The Journal of Technology Studies (JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc, a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0305. Use this address or jots@bgnet.bgsu.edu for subscription matters or purchases.

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Two print issues per year are mailed to all members of the society and to academic and general libraries around the globe. Issues that are published on-line only, the aforementioned printed issues, and past issues are available free online at scholar.lib.vt.edu/ejournals/JTS.

The journal is currently indexed in: Current Index to Journals of Education (USA); International Bibliography of the Social Sciences (IBSS) (UK); and the International Vocational Education and Training and Research Database at <http://www.ncver.edu.au> (Australia).

Separate articles or complete issues are also available in a variety of media forms from:

ProQuest Information and Learning Co., P.O. Box 1346, Ann Arbor, MI 48106-1346

Or EBSCO Publishing, 10 Estes Street, Ipswich, Massachusetts, 01938-0682, USA

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Printed in the United States of America by Kennedy Printing Company, Findlay Ohio.

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Articles

Standards: Mathematics and Science Compared To Technological Literacy

By Franzie L. Loepp

Standards for Technological Literacy: Content for the Study of Technology was released in April 2000 by the International Technology Education Association (ITEA, 2000). This was the first attempt by the ITEA to set forth comprehensive specifications regarding what students should know and be able to do within each of four grade bands from kindergarten through 12th grade. The purpose of this article is to compare the technological literacy standards with those that have been developed for preK–2 in mathematics (National Council of Teachers of Mathematics [NCTM], 2000) and K–12 in science (National Research Council [NRC], 1996).

Developmental Process

In some ways the development of standards in the three disciplines was similar. The main reason is that other disciplines appear to have used components of the developmental process used by the NCTM. All three disciplines relied heavily on working groups to develop draft standards. They sought input from teachers, teacher educators, and professionals in their respective disciplines. Drafts of the documents were reviewed by large numbers of practitioners, and their input was used to make revisions (Dugger, 2001). By its very nature the developmental process became somewhat political. For example, Dr. John Dossey¹ said that while the majority of the leaders in the discipline favored a stronger emphasis on content in statistics, probability, and discrete mathematics, others feared inclusion of new content would detract from traditional mathematics. In the development of science standards, leaders in the subdisciplines of biology, chemistry, physics, and geology were not convinced that a single set of standards could possibly give their area of study adequate coverage.² In technology, persons from the discipline tended to want a long list (200+) of rather specific standards, whereas the advisory committee, made up of professionals from other disciplines, particularly science and engineering, strongly advised a shorter, more manageable

number.³ Nevertheless, each discipline's professional organization did publish a set of standards. Short descriptions of the processes used to develop content standards are provided below.

Technology Education

The development of the standards for technological literacy actually began in 1994 when the Technology for All Americans Project (TfAAP) funded by the National Science Foundation and NASA began to develop a *Rationale and Structure for the Study of Technology* (TfAAP, 1996). Based on this document, additional funding was received to write standards for technology education. A "standards team" made up of three groups (one for grades K–2 and 3–5; one for 6–8; and one for 9–12) was formed to write content standards. The standards team was mostly made up of technology education teachers plus a few administrators and teacher educators. These groups met periodically from 1996 through 1999, writing six drafts of the standards. The TfAAP staff refined each draft and conducted many regional reviews along with electronic reviews. A special advisory group consisting of leaders in technology education, engineering, mathematics, and science reviewed draft documents and provided valuable feedback. The NRC's standards review committee, the National Academy of Engineering special review committee, a National Academy of Engineering focus group, The National Commission for Technology for Education and elementary, middle, and high school field test sites, and hundreds of technology education teachers reviewed drafts of the document. A professional writer was hired to write the finished document that was published. See Table 1 for a listing of the Standards for Technological Literacy (ITEA, 2000). The leaders of the TfAAP are to be commended for managing this complex process (ITEA, 2000).

Mathematics

In 1986, the board of directors of the NCTM established the commission on standards

Table 1. Standards for Technological Literacy

Nature of Technology	
1. The characteristics and scope of technology	10. The role of trouble-shooting, research and development, invention and innovation, and experimentation and problem solving
2. The core concepts of technology	Abilities for a Technological World
3. The relationships among technologies and the connections between technology and other fields.	11. Apply the design process
Technology and Society	12. Use and maintain technological products and systems
4. The cultural, social, economic, and political effects of technology	The Designed World
5. The effects of technology on the environment	14. Medical technologies
6. The role of society in the development and use of technology	15. Agricultural and related bio-technologies
7. The influence of technology on history	16. Energy and power technologies
Design	17. Information and communication technologies
8. The attributes of design	18. Transportation technologies
9. Engineering design	19. Manufacturing technologies
	20. Construction technologies

Source: ITEA, 2000, pp. 211-214.

for school mathematics to improve the quality of school mathematics. As a result of the commission's efforts, standards were drafted during the summer of 1987 and revised during the summer of 1988. Four working groups appointed by the president of NCTM outlined the draft documents. Each group represented mathematics educators, including classroom teachers, supervisors, educational researchers, teacher educators, and university mathematicians. All work was authorized and reviewed by the commission. In 1989 the *Curriculum and Evaluation Standards for School Mathematics* was published and widely disseminated (NCTM, 1989).

Three years after the standards were published, leaders in NCTM noted that many in their profession thought their identification of content in mathematics was too progressive so they appointed the commission of the future of the standards in 1995 to monitor and review the 1989 standards. By spring 1997, a Standards 2000 writing group and a Standards 2000 electronic format group were appointed, each consisting of teachers, teacher educators, administrators, researchers, and mathematicians. Their primary work was carried out in sessions during the summers of 1997 through 1999. The background information for these sessions was obtained or supported by such groups as Eisenhower National Clearinghouse, the NRC, the National Science Foundation, and NCTM's research advisory committee. Over the course of the development of Standards 2000, 14 association review groups were

formed to provide sustained advice and information regarding K–12 mathematics consistent with their organization's perspective. In October 1998, a draft version of the standards was available in print and electronic forms for review. Twenty-five people from a wide range of backgrounds were commissioned to carefully review the draft from their individual perspective. Comprehensive reviews were conducted by more than 650 individuals and more than 70 groups. Nearly 30,000 copies of the draft were provided to interested persons, and thousands accessed the electronic copy. These data were synthesized and provided to a writing group which produced the final document that was disseminated as *Principles and Standards for School Mathematics in April 2000* (NCTM, 2000). See Table 2 for a listing of the content standards for mathematics.

Science

The success of standards in mathematics as well as Project 2061, sponsored by the American Association for the Advancement of Science (AAAS, 1993), caused leaders in science education to initiate the development of national science education standards. The National Science Teachers Association (NSTA) board requested the NRC to coordinate this important task. The U.S. Department of Education and the National Science Foundation provided major funding for this effort. An oversight group, National Committee on Science Education Standards and Assessment (NCSESA), was established. A chairperson was selected and a chair's advisory committee was

Table 2. Mathematics Standards

1. Number and operations
2. Algebra
3. Geometry
4. Measurement
5. Data analysis and probability
6. Problem-solving
7. Reasoning and proof
8. Communication
9. Connections
10. Representation

Source: NCTM, 2000, pp. ix–xiii.

formed with representation from at least eight professional organizations. This group helped to identify and recruit staff and volunteers for the committees and three working groups (content, teaching, and assessment). Over an 18-month period, input on standards was received from a large number of teachers, scientists, science educators, and other interested parties. Many presentations were made to foster discussion on standards within the discipline. Then a predraft of science content, teaching, professional development, program, and system standards were written and critiqued by selected focus groups. The suggestions received were collated and analyzed, revisions were made, and a document was prepared for public release and review. Approximately 18,000 individuals and 250 groups reviewed this edition. The comments received were again collated, analyzed, and used to prepare the final publication of the *National Science Education Standards* (NRC, 1996). Table 3 includes the science content standards.

Cognitive and Process Standards in T/M/S

In comparing the technology/mathematics/science (T/M/S) content standards, it is interesting to note that science has the fewest with 8, mathematics has 10, and technology has 20. All three disciplines include within their designation of “content standards” standards that are clearly process oriented. Mathematics has the most process-oriented standards with 5; technology, 3; and science, 1+. The process standards in mathematics are problem solving, reasoning and proof, communication, connections, and representation; in technology they are apply the design process, use and maintain products and systems, and assess the impact of products and systems; and in science

Table 3. Science Standards

1. Unifying concepts and processes
2. Science as inquiry
3. Physical science
4. Life science
5. Earth and space science
6. Science and technology
7. Science in personal and social perspectives
8. History and nature science

Source: NRC, 1996, pp. 13–15.

the primary process standard is science as inquiry, but science and technology has a process element as well. Of special interest is the fact that a discipline such as technology education that has traditionally been highly process oriented only developed three process standards. It can be argued that if these three processes are used in all seven contexts presented in “The Designed World” section, they actually will have high priority in the design of curricula.

Table 4 also shows the number of second-level statements (technology refers to them as benchmarks) in each set of standards, the grade bands in each set, the date the standards were issued, and the Web site where more information can be obtained. With several mouse clicks one can access the entire standards documents in mathematics and science. This makes accessibility quick and affordable.

Source

Each of the disciplines has strategies or standards that are designed to complement or help implement their standards. Along with content standards, science has developed teaching, professional development, assessment, program, and system standards. Mathematics has “principles” within their standards document to set forth the basic precepts that are fundamental to a high-quality mathematics program. The TfAAP has plans to develop assessment, program, and professional development standards by 2003. All three disciplines have implementation workshops or “institutes” to help teachers in the field learn to use the standards. Table 5 indicates topics included in the mathematics and science standards. Similar topics are under development for the technological literacy standards.

Table 4. Comparison of T/M/S Content Standards

Area	# of Stds	Second Level (9-12) Statements	Grade Bands	Date Issued	Website
TECH	17 cognitive 3 process	51 cognitive 15 process	K-2 3-5 6-8 9-12	2000	www.iteawww.org
MATH	5 cognitive 5 process	71 cognitive 18 process	PreK-2 3-5 6-8 9-12	1989/2000	www.nctm.org
SCIENCE	7 cognitive 1 process	27 cognitive 2 process	K-4 5-8 9-12	1995	www.nas.org

Comparison of Similar Standards

Each of the disciplines advocates a particular way to solve problems. In technology this is called design, in mathematics it is problem solving, and in science it is called inquiry. Science also includes design as a part of the science and technology standard. Table 6 illustrates these specific problem-solving strategies. Notice the overlap between the disciplines—particularly between technology and science. Also note the different way each discipline uses the word *connections* in Table 6.

The Impact of Standards on Technology, Mathematics, and Science Education

The impact of the standards for technological literacy is treated separately because there are unique issues. There are a number of positive developments. Support has been received from the engineering community (Gorham, 2002; Wulf, 2000); program standards (Martin, 2002) and assessment standards (Custer, 2001) are on schedule to be completed in 2003 (Dugger, 2001); the NSF has continued to fund the development of curricula based on standards (ITEA, 2002); some states are revising their standards (Mino, Kane, & Novak, 2001; Newberry, 2001); publishing companies are scrambling to produce new textbooks; workshops are being conducted on how to implement

the standards⁶; some teacher education programs are changing to be more in alignment with the standards⁷; and new standards-based curricula are being developed by the discipline as well as the Center to Advance the Teaching of Technology & Science (CATTS), which is sponsored by the ITEA. However, many questions such as the following remain to be answered: Will technology education become a regular offering in the general education of all K–12 students? Will the human resources (teachers, administrators, teacher educators, etc.) be available to respond to the need for increased involvement in schools? Will technology education become more closely aligned with academic rather than vocational subjects?

The NCTM (not the federal government) identified the need for a common set of expectations so that states would have a guide to follow as they provided direction in preK–12 mathematics. Leaders in NCTM worked hard to develop a document that would be comprehensive and usable by the organization's constituents. These leaders were actually surprised at the impact their first set of standards had.⁸ Because of their success, other disciplines followed suit. Let us look at some of the ways mathematics and science standards have influenced education.

1. Nearly all states have used the curriculum

Table 5. Work Completed Beyond Standards

Technology	Mathematics	Science
To be developed (2003)	Principles Equity	Teaching standards Prof. dev. standards
Assessment standards		
Program standards	Curriculum	Assessment standards
Prof. dev. standards	Teaching Learning	Program standards System standards

and evaluation standards for school mathematics (NCTM, 1989) and national science education standards (NRC, 1996) when developing their own goals or frameworks for math and science for their state. One notable exception is in California where the science standards are more knowledge than process oriented.

2. Significant funding (National Science Foundation, Eisenhower, U. S. Department of Education, Science Literacy, etc.) for the development of mathematics and science curricula as well as for professional development has focused on the implementation of mathematics and science standards.
3. Nearly all textbooks in mathematics and science claim to be “standards-based.”
4. Nearly all teacher education programs have changed to be in alignment with the standards. Discipline-specific
- National Council for the Accreditation of Teacher Education (NCATE) standards for accreditation are also congruent with these standards.
5. Manufacturers and vendors have designed, packaged, and marketed standards-based materials to support teaching and learning in math and science.
6. State and national leaders use the standards to lobby for more resources.
7. The state and national tests now purport to be based on mathematics and science standards. Now that there is common understanding as to what students should know and be able to do, the development and use of standardized tests has become more prevalent.
8. Both sets of standards advocate a new kind of pedagogy—one that is based on research in the areas of teaching and learning, cognitive science, and the function of the brain. This new pedagogy is

Table 6. Comparison of Similar Standards (9-12 BAND)

Technology	Mathematics	Science
<p><i>Apply the design process</i></p> <ul style="list-style-type: none"> Clearly identify design problem Identify criteria and constraints Refine the design Evaluate the design Develop a product or system Reevaluate solution 	<p><i>Problem solving</i></p> <ul style="list-style-type: none"> Build new mathematical knowledge Solve problems that arise in mathematics and in other contexts Apply and adapt a variety of appropriate strategies to solve problems Monitor and reflect on the process of mathematical problem-solving 	<p><i>Science as inquiry</i></p> <ul style="list-style-type: none"> Identify questions and concepts that guide scientific investigations Design and conduct scientific investigations Use technology and mathematics to improve investigations and communications Formulate and revise scientific explanations and models using logic and evidence Recognize and analyze alternative explanations and models Communicate and defend a scientific argument <p><i>Science and technology</i></p> <ul style="list-style-type: none"> Define a problem or design an opportunity Propose designs and choose between alternative solutions Implement a proposed solution Evaluate the solution and its consequences Communicate the problem, process, and solutions
<p><i>The relationships among technologies and the connections between technology and other fields</i></p> <ul style="list-style-type: none"> Technology transfer Innovation and invention Knowledge protection and patents Technological knowledge and advances of science and mathematics and vice-versa (ITEA, 2000) 	<p><i>Connections</i></p> <ul style="list-style-type: none"> Recognize and use connections among mathematical ideas Understand how mathematical ideas interconnect and build on one another to produce a coherent whole Recognize and apply mathematics in contexts outside of mathematics (NCTM, 2000) 	<p><i>Science in personal and social perspectives</i></p> <ul style="list-style-type: none"> Personal and community health Population growth Natural resources Environmental quality Natural and human induced hazards Science and technology in local, national, and global challenges (NRC, 1996)

referred to as “constructivism” and places emphasis on allowing students to use prior knowledge to new understandings through hands-on, authentic experiences. A careful review of Tables 7 and 8 will help the reader understand the shift in pedagogy from one that is knowledge-based (memorization) to one that engages students in science and mathematics for the purpose of building understanding.

9. The new pedagogy has made it necessary for teachers and administrators to engage in extensive professional development activities.
10. The new pedagogy has also made it necessary to make substantial improvements in facilities.

Personal Experience with Standards

As the director of the integrated mathematics, science, and technology middle school curriculum development project for the past 10 years, this author has had extensive experience in the use of T/M/S standards. Clearly, standards are not curriculum, but they are extremely useful for those who develop curriculum because (a) they provide the scope of content to be included, (b) they give an indication as to what students should know and be able to do for each grade band, (c) they indicate the topics to be included in each grade band, (d) they offer some guidance as to how much priority or time should be devoted to a given topic, and (e) they provide valuable input into the development of student assessments.

Of the three sets of standards, the mathematics standards have been the most useful for those who develop curricula. Each standard tends to be of equal importance, although some standards have higher priority in some grade bands. When one considers the preK–12 bands together, each standard tends to be of equal importance. Each standard is broken into approximately 70 developmentally appropriate subtopics, so it is very clear what students should know and be able to do as they reach the end of a grade band.

Science standards are less user-friendly because they are written in more general terms. In some cases this makes the determination of

whether a learner has achieved a standard left to subjective judgment. When a standard has multiple components, the student may have achieved one aspect of the standard very well but another aspect less well. Then it is left to the curriculum developer or teacher to decide if more time needs to be spent on the achievement of the standard. Experience with aligning an integrated mathematics, science, and technology curriculum for at least 20 state frameworks reveals that national standards have influenced their state frameworks. However, in some states the national standards in both mathematics and science are broken down one more level to give more specificity and, thus, clarity as to what content children are expected to master by a given grade level.

The technology standards have definitely expanded the cognitive content to be mastered within the discipline. We have found that most of this added content can be integrated into the application of the three process standards. One problem with the technology standards is that they are inconsistent as to their scope. In other words, some are rather specific and can be mastered in a short amount of time and others are so comprehensive that it could take many class periods to accomplish. Also, the conceptual development of each of the standards from K–12 is in need of improvement. The author has used the standards for technological literacy (ITEA, 2000) on a daily basis since they were released, and he is most appreciative of the direction they provide. However, he would advocate taking a page from the mathematics educators who began to make plans for the revision of their standards three years after they were first released.

Summary

Since the mathematics standards published in 1989 had such a positive impact on the teaching and learning of mathematics, most academic disciplines have developed their own set of standards. In this era of accountability in preK–12 education, content standards play a central role. They define what students should know and be able to do. More and more they are used to develop standardized tests for specific grade levels. This is causing instruction and assessment to be squarely focused on standards, especially in the required subject areas. Although technology

education is only required in 14 states (Newberry, 2001), the discipline is fortunate to have content standards and the resources to develop professional development, assessment, and program standards. Together these standards have the potential to make a positive impact on the technological literacy of future generations (Bybee, 2002).

Dr. Franzie L. Loepp recently retired from the Department of Technology at Illinois State University where he served as the Director of the Integrated Mathematics, Science, and Technology (IMAST) Project from 1992-2003. He is a member of the Gamma Theta Chapter of Epsilon Pi Tau and Loepp received his Distinguished Service Citation in 2000.

Table 7. Changing Emphases in Science Education

FEDERAL SYSTEM	
Less Emphasis On <ul style="list-style-type: none"> Financial support for developing new curriculum materials not aligned with the <i>Standards</i> Support by federal agencies for professional development activities that affect only a few teachers Agencies working independently on various components of science education Support for activities and programs that are unrelated to <i>Standards</i>-based reform Federal efforts that are independent of state and local levels Short-term projects 	More Emphasis On <ul style="list-style-type: none"> Financial support for developing new curriculum materials aligned with the <i>Standards</i> Support for professional development activities that are aligned with the <i>Standards</i> and promote system-wide changes Coordination among agencies responsible for science education Support for activities and programs that successfully implement the <i>Standards</i> at state and district levels Coordination of reform efforts at federal, state, and local levels Long-term commitment of resources to improving science education
STATE SYSTEM	
Less Emphasis On <ul style="list-style-type: none"> Independent initiatives to reform components of science education Funds to improve curriculum and instruction based on the <i>Standards</i> Frameworks, textbooks, and materials based on activities only marginally related to the <i>Standards</i> Assessments aligned with the traditional content of science education Current approaches to teacher education Teacher certification based on formal, historically-based requirements 	More Emphasis On <ul style="list-style-type: none"> Partnerships and coordination of reform efforts Funds for workshops and programs having little connection to the <i>Standards</i> Frameworks, textbooks, and materials adoption criteria aligned with national and state standards Assessments aligned with the <i>Standards</i> and the expanded view of science content University/college reform of teacher education to include science-specific pedagogy aligned with the <i>Standards</i> Teacher certification that is based on understanding and abilities in science and science teaching
DISTRICT SYSTEM	
Less Emphasis On <ul style="list-style-type: none"> Technical, short-term, in-service workshops Policies related to <i>Standards</i>-based reform Purchase of textbooks based on traditional topics Standardized tests and assessments unrelated to <i>Standards</i>-based program and practices Administration determining what will be involved in improving science education Authority at upper levels of educational system School board ignorance of science education program Local union contracts that ignore changes in curriculum, instruction, and assessment Knowing scientific facts and information Studying subject matter disciplines (physical, life, earth science) for their own sake Separating science knowledge and science process Covering many science topics Implementing inquiry as a set of processes 	More Emphasis On <ul style="list-style-type: none"> Ongoing professional development to support teachers Policies designed to support change called for in the <i>Standards</i> Purchase or adoption of curriculum aligned with the <i>Standards</i> and on a conceptual approach to science teaching, including support for hands-on science materials Assessments aligned with the <i>Standards</i> Teacher leadership in improvement of science education Authority for decisions at level of implementation School board support of improvements aligned with the <i>Standards</i> Local union contracts that support improvements indicated by the <i>Standards</i> Understanding scientific concepts and developing abilities of inquiry Learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science Integrating all aspects of science content Studying a few fundamental science concepts Implementing inquiry as instructional strategies, abilities, and ideas to be learned
CHANGING EMPHASES TO PROMOTE INQUIRY	
Less Emphasis On <ul style="list-style-type: none"> Activities that demonstrate and verify science content Investigations confined to one class period Process skills out of context Emphasis on individual process skills such as observation or inference Getting an answer Science as exploration and experiment Providing answers to questions about science content Individuals and groups of students analyzing and synthesizing data without defending a conclusion Doing few investigations in order to leave time to cover large amounts of content Concluding inquiries with the result of the experiment Management of materials and equipment Private communication of student ideas and conclusions to teacher 	More Emphasis On <ul style="list-style-type: none"> Activities that investigate and analyze science questions Investigations over extended periods of time Process skills in context Using multiple process skills-manipulation, cognitive, procedural Using evidence and strategies for developing or revising an explanation Science as argument and explanation Communication science explanations Groups of students often analyzing and synthesizing data after defending conclusions Doing more investigations in order to develop understanding, ability, values of inquiry and knowledge of science content Applying the results of experiments to scientific arguments and explanations Management of ideas and information Public communication of student ideas and work to classmates

Source: National Science Education Standards, 1996, p. 113.

Table 8. Summary of Changes in Content and Emphases in 9-12 Mathematics

Topics To Receive Increased Attention	Topics to Receive Decreased Attention
Algebra <ul style="list-style-type: none"> The use of real-world problems to motivate and apply theory The use of computer utilities to develop conceptual understanding Computer-based methods such as successive approximations and graphing utilities for solving equations and inequalities The structure of number systems Matrices and their applications Geometry <ul style="list-style-type: none"> Integration across topics at all grade levels Coordinate and transformation approaches The development of short sequences of theorems Deductive arguments expressed orally and in sentence or paragraph form Computer-based explorations of 2-D and 3-D figures Three-dimensional geometry Real-world applications and modeling Trigonometry <ul style="list-style-type: none"> The use of appropriate scientific calculators Realistic applications and modeling Connections among the right triangle ratios, trigonometric functions, and circular functions The use of graphing utilities for solving equations and inequalities Functions <ul style="list-style-type: none"> Integration across topics at all grade levels The connections among a problem situation, its model as a function in symbolic form, and the graph of that function Function equations expressed in standardized form as checks on the reasonableness of graphs produced by graphing utilities Functions that are constructed as models of real-world problems Statistics Probability Discrete Mathematics	Algebra <ul style="list-style-type: none"> Word problems by type, such as coin, digit, and work The simplification of radical expressions The use of factoring to solve equations and to simplify rational expressions Operations with rational expressions Paper-and-pencil graphing of equations by point plotting Logarithm calculations using tables and interpolation The solution of systems of equations using determinants Conic sections Geometry <ul style="list-style-type: none"> Euclidean geometry as a complete axiomatic system Proofs of incidence and betweenness theorems Geometry from a synthetic viewpoint Two-column proofs Inscribed and circumscribed polygons Theorems for circles involving segment ratios Analytic geometry as a separate course Trigonometry <ul style="list-style-type: none"> The verification of complex identities Numerical applications of sum, difference, double-angle, and half-angle identities Calculations using tables and interpolation Paper-and-pencil solutions of trigonometric equations Functions <ul style="list-style-type: none"> Paper-and-pencil evaluation The graphing of functions by hand using tables of values Formulas given as models of real-world problems The expression of function equations in standardized form in order to graph them Treatment as a separate course Add to program Add to program Add to program

Source: NCTM, 1989, pp. 126-127.

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A Model for Unified Science and Technology

By Roy Q. Beven and Robert A. Raudebaugh

The Problem

Scientific concepts and processes are best developed in the context of technological problem solving. However, even some of the best secondary science curricula are weak in technology education and visa versa. A goal of technology and science education is to integrate student learning of science and technology. This is evident in the theme and papers of the 1996 Jerusalem International Science and Technology Conference and the efforts of the National Science Foundation, the American Association for the Advancement of Science (Project 2061, 1990), the National Research Council (National Science Education Standards, 1995), and The International Technology Education Association (Standards for Technological Literacy, 2000).

Science and Technology

Humans first used technology in a very intuitive way. Prehistoric evidence indicates that people learned to use the materials at hand, mostly stones and tree branches, to fashion simple tools to aid in gathering food and providing security. Discoveries of copper, bronze, and iron were mostly accidental, and their use in tools and weapons mostly intuitive. During the Renaissance, craft guilds were formed and the skills and knowledge of technology became more formalized, but it was still developed primarily through trial and error by highly creative and intuitive individuals. As societal needs grew and the demands on technology grew more sophisticated, links to the scientific community were forged, giving rise to formal engineer-

ing. According to Shamos (1995), "the more complex forms of technology, which could prosper only through painstaking design, eventually gave rise to the formal disciplines of engineering, whose main objective is to reduce the purely empirical content of technology, to make it, in effect, more 'scientific'" (p. 70).

This link has also been recognized in Project 2061: Science for All Americans (American Association for the Advancement of Science [AAAS], 1990) as evidenced by the following statement: "But just as important as accumulated practical knowledge is, the contribution to technology that comes from understanding the principles that underlie how things behave—that is from scientific understanding" (p. 26).

Shamos (1995) also recognized the mix of science and technology as an interdependent relationship in which technology uses the tools of science, which by extending human capability allows us to harness or modify nature to our needs. Project 2061 (AAAS, 1990) described this relationship as one in which

scientists see patterns in phenomena as making the world understandable; engineers also see them as making the world manipulable. Scientists seek to show that theories fit the data; mathematicians seek to show logical proof of abstract connections; engineers seek to demonstrate that designs work. (p. 27)

This relationship is again described in the *Technology for All Americans* (International

Science is a study of the natural world, and technology extends people's abilities to modify that world. Science and technology are different, yet symbiotic. Technology is much more than applied science and science is quite different from applied technology. When people use technology to alter the natural world, they make an impact on science. Science is dependent upon technology to develop, test, experiment, verify, and apply many of its natural laws, theories, and principles. Likewise, technology is dependent upon science for its understanding of how the natural world is structured and how it functions. (p. 28)

Teaching Science and Technology

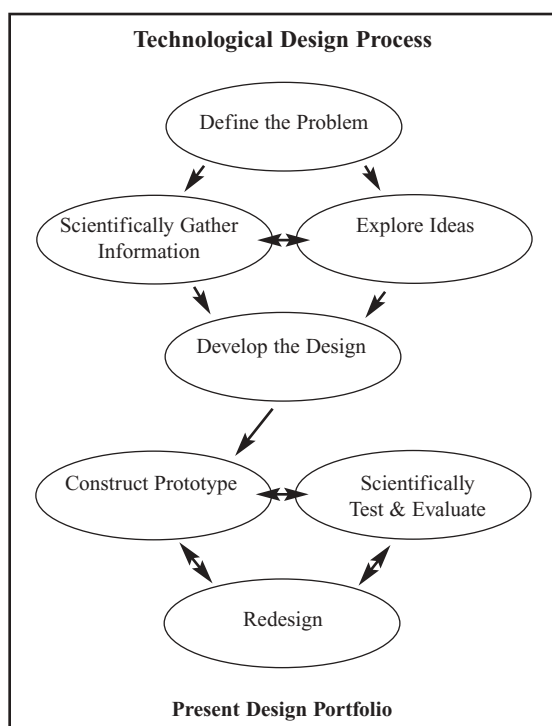
Today, probably as a result of the concerted drive during the past few decades to introduce technology education into the schools, science and technology are often considered one and the same. The problem with this is that most of what society experiences are the end products of scientific inquiry, namely those produced by technology, and almost all so-called science-based societal issues are actually based in

technology rather than in science.

Hence painting both with the same broad brush is a disservice not only to the science and technology communities, but also to society, which must understand that technology is fundamentally a social activity and that the social and economic forces which prompt technologists to modify nature are very different from those that motivate scientists to seek ways of understanding. (Shamos, 1996, pp. 68)

Obviously one cannot deal effectively with the nature of science solely in the abstract; it must be placed in the context of science itself, both for example and emphasis. According to Shamos (1995), educators now know that given a choice between stressing science or technology for the general student, the better choice is technology. But this poses a problem in respect to certain topics because technology is not the best exemplar of many of these, while science is. It is easy to focus a curriculum on technology alone, but such a program would not convey an awareness of how science works, which should be science education's main objective. Hence, both science and technology must have their own roles in the proposed curriculum, with the former used mainly to depict science process but with the actual content leaning heavily on technology.

Figure 1. Format for Learning and Curriculum Design



This is more easily said than done because it brings us full circle to the question of how to present science to the general student in a meaningful fashion, something we have not managed to do well in the past. "The obvious answer, we believe, is to begin with technology, with problems that evoke familiar images of one's common experiences, and use these to work back to the underlying science needed to deal with such questions as scientific truth, laws and theories" (Shamos, 1995, p. 224-225).

To help guide students toward the kind of scientific awareness that Shamos (1995) believed to be the appropriate objective of general education in science, science education must sharply change the emphasis of conventional curricula from science content to the process of science, continually stressing technology.

One Proposed Solution

The relationship between science and technology is so close that any presentation of science without developing an understanding of technology would portray an inaccurate picture of science (National Academy of Sciences [NAS], 1996). The key to a unified approach for science and technology lies in the use of the Technological Design Process as the format for learning and curriculum (see Figure 1). The model presented here represents a unified science and technology curriculum with a transportation theme for the middle grades. Students are engaged in the design-build process involving familiar concept vehicles and research of pertinent information in a scientific manner. Thus, students build the

middle school science ideas associated with these vehicles while developing an understanding of the design process and building technical skills.

Curriculum Design

The curriculum model in Figure 2, which the authors have titled “Move with Science and Technology,” is composed of a unifying project and four related units of study. Students are hooked into the notion of vehicle design with a quick, fun paper-car activity. They are then given the overall design challenge: design and build a human/hybrid-powered vehicle that addresses safety and environmental and transportation problems for the future. To help them in this unifying project, they will be guided through four instructional units of study.

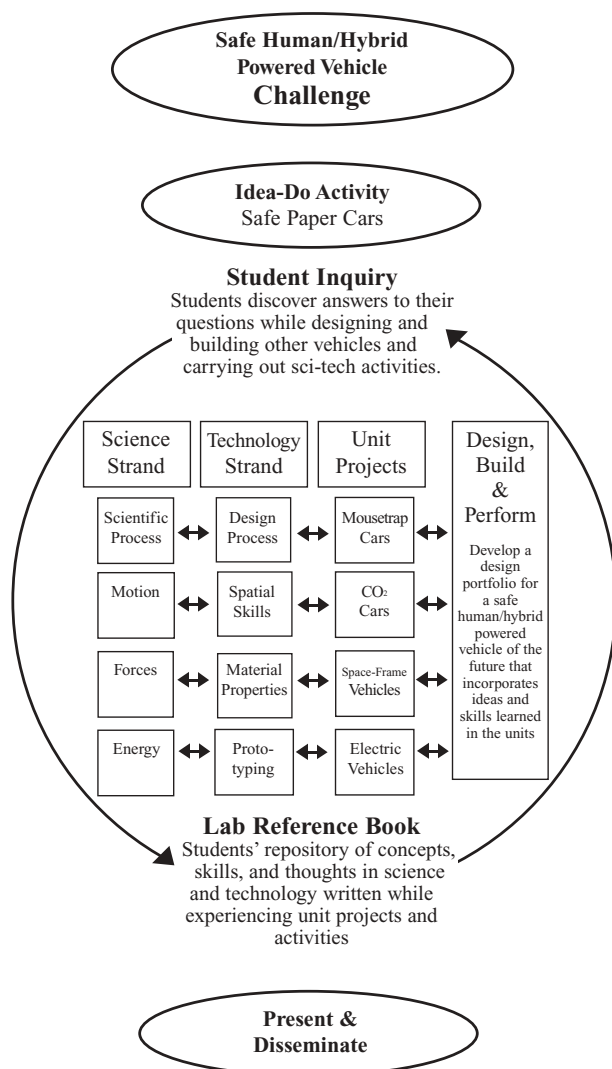
Each unit challenges teams of students to design and build concept vehicles. The result of each design process is written up in individual design portfolios and presented by the team to the class. These vehicles are somewhat familiar middle school technology projects: a mousetrap car, CO₂ car, space-frame vehicle, and an electrically powered vehicle. These units build hierarchical science and technology process skills and make a complete science and technology curriculum, especially when tied together with the unifying project. The four units can be used as stand-alone units, but the unifying project adds greatly to the real-world authenticity of the curriculum.

Throughout the curriculum, students return to the unifying project—safe human/hybrid-powered vehicles. As they move through this design process, they employ the ideas and skills developed in the units. The prototype of their human/hybrid-powered vehicle should be, but does not necessarily have to be, a working prototype. The overall assessment of this and the smaller projects is based upon their documentation of the design process, not how well their project actually works.

Conceptual Development

This unified science and technology model is guided by the National Science Education Standards mandate to supplement middle-level science coursework with “activities that are meant to meet a human need, solve a human

Figure 2. Move with science and technology curricular design



problem, or develop a product” (NAS, 1996, p. 161). Current trends in technology education include providing middle-level students with activities that allow them to develop “real technological products, systems, and environments” (ITEA, 1996, p. 38) and the recognition that “some technological problem are best solved through [scientific] experimentation” (ITEA, 2000, p. 110).

The human/hybrid-powered vehicle is the central challenge that ties together the four smaller design-build units of this curriculum. These four units build the necessary ideas, knowledge, and skills required to design and build a human/hybrid-powered vehicle.

An additional goal of this curriculum is the understanding of the risks associated with vehicles and how to reduce those risks. Students learn that “science cannot answer all questions and technology cannot solve all human problems or meet all human needs” (AAAS, 1990, p. 169). This curriculum recognizes that middle-level students can “begin to develop the ability to assess the impacts of [technological products and systems] on individuals, society, and the environment” (ITEA, 1996, p. 38). Thus, the activities are designed to allow students to learn the what, how, and why of human safety associated with vehicles.

From the first activity, paper cars, students recognize the need to have an energy source that results in a force forward on their vehicle in order to cause the vehicle to move in the desired direction. The relationship between energy, force, and motion is a common theme in each of the design-build activities. The goal is to “provide concrete experiences on which a more comprehensive understanding of force can be based” (NAS, 1996, p. 149). Specifically, students are asked to describe the motion, identify the forces causing it and the energy source in each of the design-build activities, and develop the ability to do this through well-connected science and technology instructional activities. These activities help students develop the concept of energy because they may “have some of the same views of energy as they do of force—that it is associated with animate objects and is linked to motion” (NAS, 1996, p. 154). In addition,

students are repeatedly asked to describe energy transfers because middle level students “improve their understanding of energy by experiencing many kinds of energy transfer” (NAS, 1996, p. 154).

Another theme of Move with Science and Technology is establishing the meaning and use of scientific inquiry. All the instructional activities “engage students in identifying and shaping an understanding of the question under inquiry” (NAS, 1996, p. 144). The use of a centering design-build activity provides relevant and meaningful context so that students “know what the question is asking, what background knowledge is being used to frame the question, and what they will have to do to answer the question” (NAS, 1996, p. 144).

Unit Design

Each unit challenges teams of students to design and build a vehicle, create a design portfolio, and present their design to the class. As described above, these vehicles are somewhat familiar middle school technology projects: a mousetrap car, CO₂ car, space—frame (crash test) vehicle, and an electrically powered vehicle. These units build hierarchical science and technology process skills. Each unit has eight instructional activities, including four in science and four in technology, all centered upon scientific research and the design process for these concept vehicles. The instructional activities associated with the *scientifically gathering information* and *scientifically testing and evaluation* phases are exemplary science investigations in which a controlled experiment is

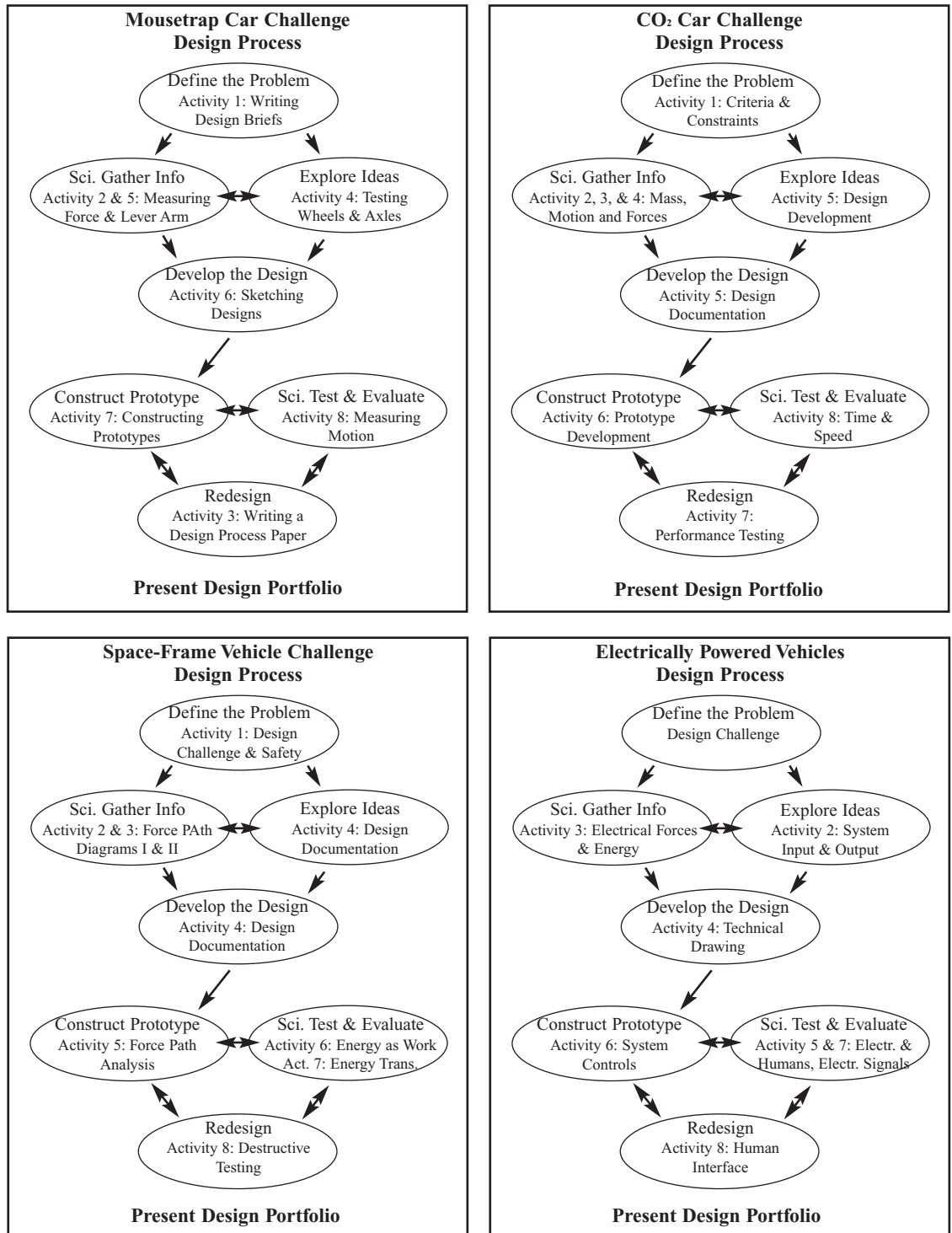
Figure 4. Suggested unit assessment



self-evident. Instructional activities associated with *define the problem* phase help students write design briefs while learning about criteria and constraints. Activities associated with *exploring ideas* and *developing the design* lead students through an exemplary sketching and technical drawing process described in an extensive supplemental piece.

In the units, the unification of science and technology is so seamless that students are focused upon a design process involving scientific inquiry and not, unless queried, aware of which activity is science and which is technology. At the completion of each unit, students are asked to write an expository paper documenting their design process. Students are then asked to

Figure 3. Unit summaries with activities and their association to the design process.
Move with Science and Technology Units



create a personal showcase portfolio composed of this technical paper and all the activities and notes of this unit as artifacts. To bring closure to each unit, student teams are invited to present their composite design portfolio to the class, including their vehicle and other artifacts of their design process. Figure 3 shows each unit, the eight activities, and how these activities are associated with phases of the design process.

Assessment

Student achievement in this model can be assessed, as prescribed in the curriculum, as a balance between students' performance in instructional activities, writing in their design process papers and notebooks, and their compiled portfolios and presentation. This balance, shown in Figure 4, indicates suggested weights of each of the artifacts. As students move through the four units and on to the unifying project, more and more weight can be put on the portfolio and its presentation.

The authors have developed, tested, and published the curriculum "Move with Science

and Technology" as described in this article.

Currently, the National Science Teachers Association (NSTA) Press, through a cooperative agreement with the National Highway Traffic Safety Administration, is publishing three of the units shown in Figure 3 in a curriculum guide called Fender Bender Physics. This curriculum guide includes student pages designed for reproduction as in-class materials and an associated teacher's guide that helps with the delivery of each unit and activity. Fender Bender Physics also contains a supplemental materials section that is written in grade-level, relevant terms intended for the instructor and/or students. Fender Bender Physics is currently available for on-line purchase at the NSTA Website, <http://www.nsta.org>.

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Technology Education Versus Liberal Arts Education?

By Oscar Plaza

This work analyzes the positioning of technology education within the tradition of classical liberal arts education. I propose ideas for mutual enrichment of classical liberal arts disciplines alongside technology education.

It is my contention that technology education is general education for a technological world. Indeed, there is a correlation between the purpose of critical thinking of general education and being surrounded by artifacts. Yet, thinking and making are inseparable. Both actions inform each other.¹ The design and problem-solving activities that are at the core of technology education do provide an excellent setting for developing qualities such as work habits, decision-making skills, effective use of resources, skills to interact positively with others, and ability to locate, evaluate, and act upon information of all kinds.¹ All these skills are transferable not only to the workplace, but to the making of a competent and humanistic person as well.² More and more all work activities, including traditional professions, are becoming service related depending upon complex technological systems.³ To understand and manage those systems requires a great deal of technology education.⁴ The contribution of services was put at the bottom during the industrial era. Now, service delivery promises the most intellectually challenging and technically difficult tasks of the future.⁵

An Inquiry In Common Ground

My proposition is to create a common ground on which to build an educational approach that eliminates the sharp cleavage between liberal arts education and technology education.

Worldview Models

My starting point is the concept that all academic disciplines have a worldview in mind. No matter how small the focus of their lenses, they see the whole world through those lenses. But, we cannot identify “betterness” looking at an academic discipline through the lens of another. Then, my proposition is to accept the

idea that each discipline carries a worldview that deserves the same academic respect. This respect will be tested when confronting an issue. The day we think that all issues must be thought of in conjunction with colleagues from different fields, we will be really serious about other worldviews.

Principles

The practice of any discipline implies the guidance of certain principles. Each of us knows that the set of principles we follow is useful to the progress of our discipline. We know other disciplines have their own principles and that probably they are useful to their endeavors. Usually, we do not give attention to the principles of others. However, principles shape the soul of a practitioner. If we are serious about common ground, we should start by attempting to understand the principles of other disciplines.

Technology education cultivates an intellectual domain; therefore, it has developed principles. It has a body of knowledge about how people create, produce, use, and assess human-made artifacts. It has a mode of inquiry that focuses on the practices of invention, innovation, and design. Technology is as ancient as civilization (Dorn & McClellan, 1999; Pacey, 1990), and this historical asset means that technology studies are foundational to any thorough educational process.

Education as a Continuum

Given equally valued worldviews and principles, we could see the educational process and system as a continuum. Education as a continuum does not move from one discipline to another (such as from one discrete point to another), but instead observers in this continuum would search for different perspectives. Liberal arts and technology education would not be different compartments, but they would have different perspectives on addressing the same reality.

In a continuum model of education, we would address any issue simultaneously from

the liberal arts and technology education points of view. Practitioners in both fields would engage each other not only for the sake of knowing and understanding the other, but for accomplishing their own aims. We should learn that we cannot address what we must by just getting more involved in our own worldview.

Education as a continuum is not symbiosis or syncretism. Technology education and liberal arts maintain their own identities but they realize that they cannot educate the educand of the future on their own. Liberal arts would learn that tools not only enhance human physical abilities, but also shape human comprehension abilities. Technology education would learn that liberal arts is not only about reflecting reality, but also about seeing reality. Education as a continuum is not about joint efforts but about intellectual honesty.

Instructional Models

Assuming a common ground for liberal arts education and technology education, we can think about common instructional models. These models should not share a common background because we try to work together. Instead, we should reach the point at which we use a common instructional background model due to the needs of our own field.

Building Up An Educational Model for the Future

The Promise of High-Tech

It was said that television was going to change schools, even displace the teacher. Teachers are still here, competing with television shows for student attention, but still here. Therefore, there is reason for skepticism about the high-tech threat to the teacher. Precisely because of high-tech, I think there are reasons for more teachers, yet another kind of teacher. The dilemma is that nobody knows exactly how this "new" teacher will look.

Information-technologies development is the key to the high-tech impact on education. Traditionally, the teacher was the authoritative sole conveyor of reliable information; not anymore. However, information is not knowledge and certainly not wisdom at all. The handling, managing, and rumination of information is becoming the big challenge of the educational

process. To "navigate" with the student throughout this ocean of information is becoming the job of the teacher.

Master/Mentor/Facilitator

The role and model of the teacher of the future are highly debated, and it will take time to reach certain consensus. Meanwhile, I propose the master/mentor/facilitator model. I think the idea combines the best of the traditional and of the "new." The master conveys the tradition of the teacher as the knowledge/wisdom authority. The mentor brings the idea of the lighthouse, of someone always there for encouragement and guidance. And, who is going to navigate with the student in the new high-tech school? We need the facilitator. Yet, the teacher will still be the commissioner of an academic discipline whether traditional or not. The teacher will still convey the meaning and excitement of a subject matter.

Multicurricula

The multicurricula idea is a curriculum with many entries. There would be as many curricula as students. No matter the entry, students would have the chance to grasp the core of traditional and new disciplines and end with a specialization on his or her own.

Meanwhile, I see two approaches to the integration of liberal arts and technology education curricula. One approach calls for technology education courses tailored as part of the general education curriculum.¹ There are courses with certain tradition that follow this pattern, such as Technology and Society, Technology and Culture, and Technology and Civilization. There are also new courses that more specifically address the issues of integration and technology education as part of the liberal arts curriculum.⁶ These new course developments call for the straight integration of technology education into the liberal arts curriculum.⁷

A second approach, which I propose, attempts a more integrative manner. The idea is to make technology education a component of integrative core courses curricula. Integrative core courses are developed around an integrative topic to which many disciplines, therefore teachers,

contribute. I believe that there is no topic about nature, humanity, or metaphysics to which technology education is alien. Furthermore, technology education should come with its own topics for integrative core course development.

Integrative core courses are difficult to develop. They are more than just a lecture series course developed around a common topic delivered by instructors from different disciplines. They are a group of instructors from different disciplines addressing together a common topic. I think that the solving/problem model of technology serves well this purpose because it requires a group of people with different backgrounds to tackle an issue together.

Integrative core courses are more adequate to the multicurricula idea. The issue is not about renegotiation of educational resources allocation, especially time curriculum, or sharing of resources among the different disciplines. The issue is curricula and course structures that address the new environment of the educational process.⁸

While some may see the entire world as a stage, Jones (1997) sees the entire world as a classroom and every "one room hut" as an access point in the age of information. The

global culture is progressing at a speed that puts the educational model for the future outside the bounds of any grand design. Nevertheless, this is not a justification for giving up or for business as usual. Education will go through fundamental changes, whether we like it or not, because the outside reality will demand a replacement of the industrial era school model we have now. Nonetheless, I believe that teacher experiences provide extremely valuable advice for change, as the following quotation shows:

I am reminded of a new technology teacher who began her first teaching job in a classroom that had no equipment for the first two months. In those first two months, however, her students were guided through problem-solving activities, technology-awareness games, simple experiments, and even philosophical discussions about technology. Once the equipment arrived, she found herself teaching primarily about how to use the equipment, and her students spent more time sanding than thinking. In looking back, she remarked that she did more technology education in those first two months than she did in the rest of the school year. (Flowers, 1998, p. 8)

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Footnotes

- ¹ For philosophical developments of this idea, see Heidegger (1977) and Pitt (2000).
- ² For a detailed analysis of contemporary competency, see "Career Development and Workforce Preparation: Educational Policy Versus School Practice," *The Career Development Quarterly*, September 1996, pp. 20-37.
- ³ For a discussion of liberal arts education, see "Initiating the Conversation" and "The Classical Liberal Arts Tradition" (Glyer & Week, 1998).
- ⁴ See, for example, Pitt's (2000) definition of technology as "humanity at work."
- ⁵ See recent report by National Academy of Engineering and National Research Council (2002).
- ⁶ Rifkin (1996) analyzes the impact of technological changes on the workforce.
- ⁷ A good example is the effort of the University of Wisconsin-Stout. "Technology Is Required as University General Education," Leonard F. Sterry, paper delivered at the Annual ITEA Conference, March 23-25, 1997, Tampa, FL.
- ⁸ Examples of this kind of effort include Technology as Liberal Education: A Model Course, ITEA Task Force on Technology Education as Liberal Education, 1993; and Exploring Technology, Leonard F. Sterry and Robert W. Hendricks, T&E Publications, 1997.
- ⁹ For another discussion on integration, see "Integrating Liberal Arts and Professional Education," Christopher Flannig (Glyer, 1998).
- ¹⁰ See, Postman (1995) for a discussion of the new educational environment.



Defining the Role of Technology Education by Its Heart and Its Heritage

By Mark S. Snyder

The Committee on Technological Literacy (CTL), a group guided by the National Academies of Science and Engineering, the Institute of Medicine, and the National Research Council, recently concluded that "it is in the best interest of all Americans to understand more about technology" (Pearson & Young, 2002, p. 103). According to A. Thomas Young, the chair of the CTL, "the committee hopes technological literacy will be put 'on the map' and the way will be cleared for a meaningful movement toward technological literacy in the United States" (Pearson & Young, 2002, p. viii). The CTL recommended that governmental agencies set education policy to "encourage the integration of technology content into K-12 standards, curricula, instructional materials, [etc.]" (Pearson & Young, 2002, p. 103). If this does, in fact, occur, then technology education offers a clear solution towards helping the

committee realize its aims.

This article was written from the perspective that technology is a discipline of its own that is best taught through a variety of methods that necessarily include experiential learning. By definition, technological literacy is, and has always been, at the very heart of technology education. In fact, the phrase *technological literacy* is not new to this field—it has been in use since 1947. Although science and technology are closely linked, they are not the same; learning about science is not the same as learning about technology. Technology education has evolved from a discipline that mostly taught psychomotor skills to one that now emphasizes more cognitive as well as affective learning principles. Nonetheless, a hands-on, problem-solving instructional method is the heritage that endures as one of the best ways to

help students learn about and fully understand technology.

Of the Heart

There are numerous definitions for the term *technology*. Etymologically, it is an adaptation of the Greek word *tecnologia*, which meant a “systematic treatment of grammar,” and was formed from the root *tecnh*, meaning “art” or “craft.” Therefore, in the sense most closely related to its origin, the expression is used to signify “technical nomenclature.”

The Compact Edition of the Oxford English Dictionary (1971) identified a different use for the word, first applied around 1615. This definition of technology is perhaps the most general: “a discourse or treatise on an art or arts; the scientific study of the practical or industrial arts” (p. 3248). In this sense, technology is considered a body of knowledge, just as sociology is considered a field of study. DeVore (1980) posited that technology is indeed a discipline, which he defined as “the study of the creation and utilization of adaptive systems including tools, machines, materials, techniques, and technical means and the relation of the behavior of these elements and systems to human beings, society, and the civilization process” (p. 4).

Webster’s New World Dictionary of the American Language offers similar versions, as well as the following: “The system by which a society provides its members with those things needed or desired” (Guralnik, 1980, p. 1460). DeVore (1980) also recognized that technology exists as systems “ranging from tools, and their use, to the social impact and influence of tools, technics and products on the lives of particular individuals and groups” (p. 4).

Specific artifacts developed by human beings for the advancement of material culture can also be thought of as technologies. The CTL stated: “Technology comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves” (Pearson & Young, 2002, p. 13). Johnson (1989) wrote, “Technology is best described as a process, but it is more commonly known by its products and their effects

on society” (p. 1). This observation is tenable and seems appropriate as an explanation for the prevalent modern perception of the term.

Technology is also used at times to mean “a method, process, etc. for handling a specific technical problem” (Guralnik, 1980, p. 1460). However, in this case, the term *technique* seems more appropriate. Technique refers to the methods of procedure, or way of using basic skills, in carrying out a technical or mechanical operation.

The term *technics* describes the basic skills necessary for the utilization of techniques. DeVore (1980) defined technics as “specific technical skills associated with a particular technological act or behavior” (p. 3). In 1989, Chant wrote:

The proposed technics/technology distinction has yet to find its way into much academic, let alone popular, discourse, even though it offers a way of tidying up some of the present confusion, and perhaps further a way of relating that confusion to the central historical relations of this volume. For if technics is identified with products and processes, this leaves technology as a form of knowledge. (p. 45)

Chant’s (1989) application of the term *technics* is convenient, and yet it seems an oversimplification to contrast technics and technology. Admittedly, technology may be considered a form of knowledge, as when defined as the study of practical or industrial arts. However, technology is also an active discipline that requires a familiarity with technics and their application through techniques. Essentially, technics can be distinguished as a separate but integral element within the realm of technology.

Language may, unfortunately, introduce an obstacle to the clear understanding of this distinction. The book *Man and Technics: A Contribution to a Philosophy of Life* was an early study of technology by Spengler (1932/1960). In the translation from German, by Atkinson, the word *technics* was employed to describe Spengler’s philosophical view of technology. The author was interpreted to say:

Technics is the tactics of living, it is the inner form of which the procedure of con-

flict—the conflict that is identical with Life itself—is the outward expression... *Technics is not to be understood in terms of the implement*. What matters is not how one fashions things, but what one does with them.... Always it is a matter of purposive activity, never of things. (pp. 10-11)

Ellul's (1954/1964) *The Technological Society* was originally published in 1954 under the French title *La Technique ou L'enjeu du Siècle*. In the translator's introduction, Wilkinson interpreted this phrase literally to mean "Technology: The Stake of the Century." Wilkinson continued by stating: "*Technique*, the reader discovers more or less quickly, must be distinguished from the several *techniques* which are its elements. It is more even than the organized ensemble of *all* individual techniques which have been used to secure any end whatsoever" (Ellul, 1954/1964, p. x).

The French have since attempted to distinguish between technics and technology. Daumas (1970/1976) wrote, however, "in French the word *technologie* has no absolute meaning.... It will nevertheless remain true that the equivalent English word, technology, embraces both the French words *technique* and *technologie*" (p. 93).

In this discussion regarding the word *technology* and its related terms, it seems appropriate to offer one more passage that contains the critical elements necessary to accurately define technology: "Technology is a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (Savage & Sterry, 1990, p. 2). This seems to be a tangible definition that is concise yet complete.

Mind Over Matter?

The terms *pure science* and *applied science* have often been used as references to science and technology, respectively. Buchanan (1976) wrote the following:

Attempts to sharpen the definition with derivative terms such as "pure science" and "applied science" have tended only to convert imprecision into confusion. However, it can be agreed that there is a

distinction between science and technology in present-day practice, coinciding in general with fairly discrete professional groups. (p. 76)

Price (1975) dedicated an entire chapter of his book *Science Since Babylon* to "The Difference Between Science and Technology" (pp. 117-135), and Chant (1989) summarized Price's philosophical view of this concern when he wrote: "Technology is not applied science, but rather science and technology are parallel structures in a symbiotic, weakly interacting relationship" (p. 76).

The juxtaposition of science and technology is an issue that has been discussed for centuries. As a result, a great deal of confusion has transpired regarding the distinction between the terms. Daumas (1970/1976) wrote, "Weighing these words *science* and *technology* against one another in a rather scholastic manner each historian strives either to assimilate one to the other or on the contrary to oppose them in pretty muddled antitheses" (p. 93). Science and technology have often incorrectly been used interchangeably, and fairly strong opinions have developed regarding the perception of these concepts as separate entities. Lisensky, Pfnister, and Sweet (1985) wrote:

In discussions of technology, one finds the terms science *and* technology used in combination, as if the one cannot be considered without the other. Historically, however, technology developed without reference to science. The social process that is technology arose empirically, either by accident or as a matter of common experience. (p. 8)

The science/technology dichotomy can be perceived in a variety of ways. Ellul (1954/1964) thought technology was "autonomous" and that "science had become an instrument of techniques" (p. 10). In his book *John Dewey's Pragmatic Technology*, Hickman (1990) contended that Dewey viewed science as a "type of technology" (p. 11). Chant (1989) described what has been referred to as the *linear sequential* model of technological innovation, stating, "Science is on this account an independent variable, developing largely by way of its own internal intellectual dynamic; technology is a

dependent variable, pushed by scientific discovery and/or pulled by public and private need” (p. 42). Lisensky et al. (1985) promoted the view “that science is detached, concerned about knowledge for its own sake, while technology is more directly involved in the social process and is concerned about the solution of problems and application of knowledge to that solution” (p. 9). Johnson (1989) provided a sensible illustration of the relationship between science and technology in the following passage:

Technology is also a technical process. It is different from science, whose role is understanding. Technology’s role is doing, making, and implementing things. The principles of science, whether discovered or not, underlie technology. The results and actions of technology are subject to the laws of nature, even though technology has often preceded or even spawned the discovery of the science on which it is based. (p. 1)

Although the previous statement is a rather broad generalization, and contradictory points of view have been exemplified, this author accepts the premise of science and technology as separate, yet interactive and dependent, entities.

Heritage: The Instruction of Technics

From a historical perspective, the nomenclature surrounding this field can become a hindrance since a wide variety of labels have been applied to systems for the instruction of technics throughout the past. Apprenticeship was the earliest such organized system and has lasted for millennia. Since the advent of civil control over education, mechanical schools, polytechnics, schools of industry, mechanics institutes, lyceums, manual labor academies, technical institutes, workingmen’s schools, manual training schools, sloyd schools, public school manual and industrial arts, and vocational schools have all been systems established essentially for the instruction of technics.

In 1918, Crawshaw and Varnum described in their book *Standards in Manual Arts, Drawing and Design* the following point of view:

Manual training as the term is used in this bulletin refers to the method by which

industrial work is developed under school control. It signifies a plan by which hand, tool and machine work is made educative through a series of progressively developmental problems.

Manual arts as herein used indicates the content of the several subjects which are included in a division of the school dealing with industrial work.

Industrial education as used herein refers to the study of all or a branch of *industry* (a manual art) by means of the most approved pedagogical and industrial methods. It includes both information about and practice in industry. (p. 5)

The term *industrial education* has continued to be used as a broad heading that has more recently included all forms of technical education that, as a group, derived their content from industry, whether their focus was vocational or general education. *Manual training* gradually evolved into *manual arts*, which, in turn, influenced the development of other forms of industrial education. There is no doubt that these areas of instruction contributed to the development of yet another system of instruction referred to as *industrial arts*. In 1934, Collicott and Skinner wrote:

Industrial Arts has had its greatest development on secondary school levels. Here it has passed through two somewhat well-defined periods of professional growth and is now in the midst of a third. The first was “manual training,” where the emphasis was on *hand* skill, chiefly in woodworking. The second was “manual arts,” where the emphasis while still on skill, was extended to include the *making* of both *useful* and *well-designed* articles. The third is now “Industrial Arts,” where the intent is to include all of the old that was good, but to broaden out from the limitation of an emphasis upon manual skill alone to an enriched conception where more of the child’s interests and environment, and certainly many of the other school subjects, are involved. (State Committee on Coordination and Development, 1934, p. 5)

A similar passage by Bennett (1937) has often been cited to clear up confusion regarding the three terms used above to describe the slightly different approaches to technical instruction that chronologically overlapped during the early 20th century. It reads: "In the term industrial arts, the 'industrial' is emphasized; while in manual arts, the 'arts' is historically the distinctive word and, in the term manual training, 'manual' is the important word" (p. 455). Although there were subtle differences between these three methods, they all represented a form of instruction that used "hands-on" methods of learning technology-based content as part of a broad educational experience rather than job-specific training.

The emphasis of all these programs was on "learning by doing," but the focus of the content was always based in, or on, technology. Technology education evolved from, but is not limited to, this strong tradition of hands-on learning.

The Inception of Technology Education

In April 1947, a new interpretation of industrial arts, referred to initially as the "The New Industrial Arts Curriculum," was imparted by Warner, Gary, Gerbracht, Gilbert, Lisack, Kleintjes, and Phillips. Warner introduced this new plan at the fourth session of the eighth annual American Industrial Arts Association (AIAA) convention held in Columbus, Ohio. For Warner, it was the next logical step in the advancement of his philosophy and practices. Warner and his protégés defined industrial arts as follows:

Functionally, industrial arts as a general and fundamental school subject in a free society is concerned with providing experiences that will help persons of all ages and both sexes to profit by the technology, because all are involved as *consumers*, many as *producers*, and there are countless *recreational* opportunities for all. (Warner et al., 1965, p. 41)

Curtis wrote a review of Warner's conference presentation that was printed in the June 1947 issue of *The Industrial Arts Teacher*. He commented, "The presentation by Dr. Warner, and the interpretations that followed, completely re-

defined the position of industrial arts in general education in the public school, and solicited both re-evaluation of the present program and consideration of the implementation of the new" (p. 1).

Olson (1963) said of this effort, "It was too far ahead of the times to gain general acceptance, but like all advance thinking it has had its impact on the profession" (p. 15). Warner, himself, had a slightly different feeling about the acceptance of the project as evidenced by the following which he wrote retrospectively:

The result, as herein reported, was featured at the AIAA Convention of 1947 which I revived in Columbus, Ohio, following World War II, and where we were fearful of the outcome until the discussions which followed, when our findings were not only accepted, but praised on all sides. (Warner et al., 1965, p. 5)

Eventually, "The New Industrial Arts Curriculum" became known as *A Curriculum to Reflect Technology*, with content that was "derived via a socio-economic analysis of the technology and not by job or trade analysis as of old . . ." (Warner et al., 1965, p. 41). It included six subject matter classifications: power, transportation, manufacturing, construction, communication, and management. Latimer (1981) summarized:

For the most part, it remained a proposal, probably because Warner did not have the funds to promote and enhance it nationally. The plan was probably too far ahead of its time

Even though the curriculum was never totally implemented, today there are many elements of *The Curriculum to Reflect Technology* present in educational systems throughout the United States. (p. 48)

Gordon O. Wilber, the ninth president of the American Industrial Arts Association (AIAA), was another effective industrial arts educator with timely insight. He referred to the influence of technology in his book *Industrial Arts in General Education* when he defined industrial arts as "those phases of general education which deal with industry—its organization, materials,

occupations, processes, and products—and with the problems resulting from the industrial and technological nature of society” (Wilber, 1948, p. 2). Wilber also expressed the conviction that education was critical to the development of technology by stating: “If society did nothing more than transmit its culture there would be no progress or improvement. Education has the further objective, therefore, to provide for extending and improving the way of life” (p. 6). This could be accomplished, he believed, through instruction that challenged the critical thinking skills of students.

In 1951, Meyer, an associate professor of industrial arts and vocational education at the University of Florida, Gainesville, asked of his peers, “Industrial Arts—What Next?” Meyer knew that “every boy and girl, regardless of present interest or future occupation, is forced to an acquaintanceship with the products of technology” (p. 15). As a result he felt that “work with materials and toward a grasp of technology needs to be a part of the experience of every boy and girl” (p. 15).

Technological Literacy—The Aim of Technology Education

In 1948, Williams, who was a professor of education at the University of Florida as well as the vice president of the AIAA, declared that “Industrial Arts Faces a New Era.” In an article by that title for *The Industrial Arts Teacher*, Williams wrote the following:

For a time the true educational concept of industrial arts was lost, and its position was relegated to a secondary place in the scheme of general education. Now, under the pressure of a complex technological society the narrow view of the manual arts concept is fast giving way to a more comprehensive and flexible interpretation of industrial arts or technology. That a crucial need exists for technological literacy is apparent. (p. 1)

In suggesting one course of action, Meyer (1951) recognized that “as teachers of industrial arts, a field yet young in education, we have groped for truth and sought our role in leading youth toward a real and functioning technological literacy” (p. 16). Meyer continued by stating:

Our problem is not that of substituting something new for something old. It is not to discard the *classics* in the interest of the *technics*—for this will destroy both. Our task is to provide the cultural matrix of the arts, the sciences, and the humanities so that the equally cultural technologies can find their rightful place and make their vast and vital contribution. (p. 16)

The phrase *technological literacy* has since been employed unrelentingly by technology educators, which is appropriate since the development of technological literacy has been identified as a major goal of the discipline. In 1968, DeVore wrote:

In today’s world, when there is a greater need than ever before for technological literacy, we discover the contemporary status of the industrial arts to be one of confusion and perhaps indecision, with a few notable exceptions. Teachers in the profession, however, are becoming increasingly aware that the confusion is the result of our heritage, and indecision the result of inadequate perspective. (p. 1)

In the 1983 *Professional Improvement Plan* of the America Industrial Arts Society, the transition from industrial arts to technology education was described as “a national concern,” “a mission for education,” and “a stimulus for a new curriculum with new goals directed toward technological literacy” (Starkweather, 1983, p. 8). The plan itself identified three major goals:

- I. Pursue the ideal form of industrial arts/technology education to ensure technological literacy of all people.
- II. Profit from personnel development exercises developing and nurturing programs that apply technology to societal problems.
- III. Exchange ideas and practices within and outside the profession to foster a positive, consistent view of industrial arts/technology education. (AIAA, 1983, p. 4)

According to the goals listed, the leaders of

industrial arts education planned to improve the technological literacy of all people through innovative new programs that would involve more of the cognitive and affective content of technology and apply it to solve problems. There was also a successful movement underway to change the name of industrial arts to technology education.

In 1986, Loepp identified the need to increase the technological literacy of our citizenry as “an educational challenge.” He described six characteristics that a technologically literate person should exhibit: the ability to recognize and use the appropriate technology in given situations; anticipate undesirable outcomes of the use of technologies; identify alternate courses of action if the technology fails; understand basic mechanical, thermal, fluidic, and electronic principles utilized by technologies; gather and interpret data, or information; and use basic tools, materials, and processes of technology.

An individual who displays such capacities has not only managed to develop fundamental psychomotor skills but also the cognition of many academic disciplines. Values are also important when making decisions regarding the appropriateness and outcomes of the utilization of technologies. Hopefully, in the future, such judgments will be made from well-educated perspectives. Technology education aims to provide learners with the opportunity to develop such capabilities as described above, and therefore contribute to the growth of society.

Conclusion

The CTL has recognized a need that technology educators first identified nearly 50 years ago: Americans need to understand technology and become technologically literate. As the profession has evolved, it has become evident that technology is and has always been the very heart of what we teach.

The CTL also has distinguished a “capability” dimension of technological literacy that justifies the need for psychomotor learning by stating:

Someone who is knowledgeable about the

history of technology and about basic technological principles but who has no hands-on capabilities with even the most common technologies cannot be as technologically literate as someone who has those capabilities. (Pearson & Young, 2002, p. 22)

Technology education has taught about technology, through hands-on experiences, for a long time; most believe that to be the strongest aspect of its heritage. Another of the CTL’s conclusions is that education for technological literacy requires a multidisciplinary approach and suggests that technological literacy could be a “thematic unifier for many subjects now taught separately in American schools” (Pearson & Young, 2002, p. 23). Custer (2002), a technology teacher educator and member of the committee stated: “This should not be interpreted in any way as a devaluing of technology education. Rather, the committee clearly came to view technological literacy expansively, as a critical matter of national importance that inherently spans academic disciplines” (p. 6).

American schools are being evaluated constantly and criticized for the quality of education that they provide. Although the majority of graduates do not pursue a postsecondary liberal arts education, almost every American student is prepared as if this were the expectation. The majority of curricula in our schools is based on knowledge we have established over centuries to be “truth.” While learning these truths is necessary, understanding how these truths have been applied to our society through technology is also valuable. Maybe there are better ways for students to learn these truths—or to learn them better.

Perhaps, the field which has been continuously evolving into technology education has always been an essential educational enterprise that links classical knowledge to our culture. If this is true then a broad interdisciplinary approach involving technology education should be considered a natural outcome of general educational practice. (Snyder, 2000, p. 36)

Technology education has evolved to a point where it is uniquely positioned for meeting the aims of the CTL. The CTL itself stated:

“Technology educators are playing an increasingly important role in the development and delivery of technology-related content to students in K-12 classrooms, and technology teachers represent an important resource for attempts to boost U.S. technological literacy” (Pearson & Young, 2002, p. 80). Herein lies an opportunity for technology education to clearly define its role in the American education system. Its strength is its emphasis on the development of students’ capabilities through design and problem-solving activities, but it must find its place among a broad interdisciplinary approach and address issues related to how students think

about, and act on, technology-related issues. Technology education engenders the academic ideal of developing students who can think, and live, independently. Technology education also prepares students to apply knowledge and introduces new ideas and practices that enable individuals to perpetuate the advancement and development of a strong, safe, well-educated, and technologically literate society.

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Quality-Based Cooperative Technical Teacher Training

By László Kadocsa and Imre Kopp•ny

Hungarian higher education is in transition from the stage of elite training to that of mass education. At the same time, according to monitoring surveys, the output efficiency level of secondary school students has decreased. These aspects, combined with the narrowing resource base due to the worsening demographic conditions, call for the renewal of global higher education and particularly technical teacher training. The authors are hoping for a breakthrough in the following items: quality-based approach in training and the organization, learning-centered philosophy instead of teacher-centered philosophy, new types of study materials and evaluation strategies, modular and credit-based curricula, and cooperative training.

Cooperative Technical Teacher Training

Technical teacher education at polytechnics in Hungary has the specialty, and the advantage, of parallel engineering and teacher training at the same time. This type of dual course work aims at preparing students for two alternative professions: engineer or technical teacher at vocational secondary schools. About three quarters of the total training hours concern engineering subjects, and one quarter of those center on pedagogical subjects. At Dunaujvaros Polytechnic (DP) there is a possibility for students to learn some engineering and pedagogical subjects in English or in German as well. More than half of the graduates work for industrial companies as an engineer. Graduates who have studied professional subjects in

mechanical engineering or in information technology in foreign languages at DP are very popular, particularly at multinational firms in Hungary. Cooperative features of the training create a strong link between DP and industrial companies or other enterprises in the practical professional training of the students and between DP and vocational secondary schools in pilot teaching projects run by the students.

At the end of the sixth semester, every student spends a month at an industrial placement as an engineer assistant. In the seventh semester, there is a complex engineering project ended by a written final work and closing exam. This final work is related to the solution of a real industrial problem and is guided by an industrial expert and a supervisor of the academic staff.

Students complete a pilot teaching project in the eighth semester. The project consists of observation and trial teaching, one-month teaching practice in a vocational secondary school, and a teaching presentation. These activities are guided by a senior secondary school instructor and a supervisor of the academic staff. In the curriculum development of the technical teacher training program, theoretical and methodological aspects as follows were taken into account.

Challenge For Higher Education

Global tendencies in higher education are:

- Changing from elite training to mass education.
- Establishing common features in the national higher education systems.
- Strengthening integration and organizational restructuring.
- Gaining a multilevel character or diversification of the training.
- Enforcing institutional autonomies: constraint of the requirement of cost efficiency, development of the interconnection of higher education and research with the industry, change of paradigm in the strategy and methods of teaching and learning, improvement in quality, development of quality assurance systems, etc.

Hungarian higher education needs to follow the international tendencies of development and

to adapt some of its important elements (Altbach, 1991). At the same time, in the course of changes, we cannot forget to take into account our national cultural heritage and features to preserve the actual values existing in our higher education.

As for quantitative development, Hungarian higher education has taken a considerable step towards catching up in the end of the 1990s, shown by the doubling of the number of students. Today, 40% of the generation aged between 18 and 23 years, or more than half of the youths leaving secondary school, will enter higher education.

Research studies have shown that the efficiency of students leaving secondary school decreased in our country—mostly in those fields that have an outstanding importance from the point of view of the success of studies in higher education. For instance, primary and secondary schools today prepare their students to a less extent for complex text interpretation exercises (diagrams, tables, instructions of use, etc.), and the output of youths in the field of mathematics and natural sciences is essentially worse than one or two decades before. There is a natural demand in public education to stop this decay of the output level of students and a call for its improvement. However, in itself, this cannot create a solution, as higher education must also enhance the smooth adaptation of students into higher level studies.

Increasing numbers of students combined with a narrowing resource base due to the worsening demographic conditions, the worsening output level of students in public education, and their uncertain career image, urge higher education that was previously arranged for elite training and that has been operating multiple selection mechanisms to undergo radical changes.

We are convinced that within the framework of mass-level higher education, for the sake of maintenance and even improving of quality, it is necessary to transform and renew the vertical structure of the training, as well as the whole technology of teaching and learning.

Change Of Paradigm In The Methodology Of Technology Education

Undergoing rapid changes, there is a demanding need for a new view and paradigm in higher education, which should be student-centered, learner-centered. For this reason, higher education has to change its learning programs. The content, methods, and the practice and means of delivery (teaching and learning) of education should be based upon new partnerships between students and teachers. These new methods of teaching should go together with new types of teaching-learning materials. These new methods must also be connected with the new types of assessment and evaluation, which will enhance the development of not only the memory but also understanding and realizing capacity, as well as creativity and the capacity of doing practical work. The technology-based learning environment and the information and communication technologies as well as the application of open and distant education methods require the reformulation of the content, forms, and full practice of education. These new methods of teaching should go together with new types of teaching-learning materials.

Change Of Concept

The renewal of training should include concept and role changes, both from the part of teachers and students, as well as the renewal of contents and the creation of a study environment. This change of view from the side of teachers requires the creation of a learning, guiding, helping attitude, which can be recognized as the main managing force of the learning process. The active cognitive activity of the students should more and more be emphasized, which, at the same time, also requires the undertaking of a greater responsibility for their own learning activity.

During the renewal of the study material, a balance should be achieved between the wide basis that assures the convertibility of knowledge and the users' ("market") demands that are formulated more and more markedly. Within the transformation of the study environment, the expansion in space and time of the scenes of teaching and learning is well observable (van den Berg, 1996). The individual sites, or those that are suitable for small-group learning, play a

significant role in and outside of educational institutions: at media centers, resource centers, computer rooms, libraries, research places, homes, working placements, etc.

The main characteristics of the methodological, didactical changes are:

- The conveying of knowledge is transformed into a cognitive (knowledge-gaining) process.
- Learning to learn plays a decisive role in this process.
- The process has a student-centered character.
- The teacher loses his or her central role.
- The teacher assists the students in the organization of their learning activity.
- The teacher creates the conditions of learning, shows the direction, and gives counsel.
- The teacher explains to the student the essential interrelations, the methods of work, and the rules.
- The teacher evaluates the results.

These, altogether, can result in the achievement of a new type of relationship between teacher and student, the basic change of the structure and contents of training, and the character of teaching and learning.

Development Of Higher Education Curricula

We identify the curriculum as a process plan, a program, that is a thoughtful system of teaching and learning goals, requirements, contents, organizational-methodological-instrumental solutions, evaluations, and conditions. The structure of the curriculum determines the priorities that, at the present date, show more and more a student-centered or learning-centered tendency. In the development of the university and college curricula, the following tendencies can be observed:

1. ***The credit system becomes general:***
The credit serves for the measurement of the time for teaching, or for the measurement of the amount of the total student work necessary for the acquisition of the given subject or module. The great advantage of the credit system lies in its flexibility, which makes possible the satisfaction of the need for free

choice ("determining of the own way of life"), the permeability between the areas of study and the training stages, the reciprocal acknowledgment of the part-trainings and part-studies, the continuing of studies without time losses, the possibility of conferring an international status to the studies (European Commission, 1998).

2. **The dynamic development of the modular curriculum structure** (Badley & Marshall, 1995; Burkhart, 1996): The precondition of the optimal functioning of the credit system is modularization, which means the creation of study units, courses, and modules, as well as using them as elements in further building. The module, the unit element of the training (teaching and learning process) that is the basis of the planning and development of the curriculum, includes all the study work (lectures, practical classes, individual learning, assessment and evaluation, school practice, etc.) necessary for the processing and acquisition of a coherent part of the study material (subject or subjects). In fact, the modular curriculum system represents the basis of the credit system. The credit-based modular systems carry in themselves the joint advantages of the credit and modular systems.
3. **Flexibility:** The modules can elastically adapt to the many-faceted student community, to the rapid development of the sciences, and to the ever-changing needs of the labor market.
4. **Motivation:** The success assured by eligibility, the opportunity of forming an individual path of life, and the effective learning guidance can considerably increase the inner motivation of students, the appearance of a positive attitude, and responsibility towards learning.
5. **Wide availability:** With modularization it is possible, on one hand, for preparedness of candidates and the requirements of the study programs to meet. On the other hand, in the measure of the individualization of training and the elaboratedness of the learning guidance procedure and resource systems, it decreases the number of necessary contact hours and increases the ratio of individual learning.
6. **Adaptivity of curricula:** The module as a unit element (e.g., the standard module comprises a workload of 90 hours of total learning) can, in principle, be inserted anywhere in the curriculum, or can be changed, transformed, upgraded, etc.
7. **Enhancement of credit accumulation and transfer:** Modularized courses are characterized by the fact that the credit is allocated to the module, and the successful accomplishment of a certain module means the acquisition of the allocated credit points (e.g., if one module = 90 hours total learning workload and 1 credit = 30 hours total learning workload then 1 module = 3 credit points). Thus, the credit accumulation is achieved through the accomplishment of the modules, while possibility of the transfer (transferability, accountability) supposes modules with identical (to min. 75%) content among training programs, degree courses, and institutions.
8. **Cost efficiency:** As a result of wide availability, the cost efficiency is improving, but the elasticity has its own price. Cost efficiency can be improved if we apply "common" modules in different study programs.
9. **Promotion of the concept of lifelong learning:** The knowledge acquired in different training forms, places, and time, as well as the accountability of the practical placement, "requires" the modular and credit-based curricular form because this ensures the superposing of knowledge.
10. **Open or distant education:** Distant education is the "traditional" training

form built on modules in the shape of learning packages, which include most of the functions of learning guidance taken over from the teacher, with the assurance of consultation possibilities.

11. ***Spreading of information and communication technologies:*** They promote the re-thinking, re-formulation of the teaching materials and forms of delivery (teaching and learning) connected in most cases with distant education and/or modularization.

12. ***Enhancement of pedagogical innovation:*** Modularization, the development of learning guidance procedures and modern teaching materials, has represented the basis of the pedagogical renewal in higher education throughout the world, which can lead to the achievement of the change of concept and role (change of paradigm).

Active, independent student work is in the center of the process. From among the conditions of the effective achievement of the independent student learning activity, we can point out the following:

- Necessity of the development of learning abilities.
- Elaboration of a system of individual and group study problem solving (literature processing, exercises, projects, etc.).
- Decreasing to reasonable levels the fixed weekly number of hours ("contact hours").
- Working-out of a procedure and device systems for guided learning (learning guidance, additional learning materials, etc.).
- Upgrading of the assessment and self-assessment systems.
- Creation of a modern learning environment (computerized infrastructure, library, laboratories, tutorial system, etc.).

Quality Thinking In Education

A focus of institutional strategic management in higher education includes the demands of the stakeholders: students, staff, employers of graduates, government, and society (Bonstingl,

1997). This new way of thinking of quality in Hungarian higher and public education is characterized by some new programs:

- Hungarian Accreditation Committee organizes the evaluation of training programs and institutions in higher education (started in the mid 1990s).
- COMENIUS 2000 Quality Improvement Program aims at the implementation of the principles and practice of TQM in public education (started in 2000).

Preparation for these tasks is built in the training of technical teachers at DP. The quality development process was supported, among others, by a three-year TEMPUS-JEP project (1996-99).

The project has essentially achieved its objectives:

- The introduction of quality thinking into strategic management.
- The addition of one or more quality subjects in all of the main study areas at DP.
- The development of a new special course, Quality Control, consisting of 12 quality modules in the 3.5 year Technical Manager degree program.
- The development of a quality system at DP as well; the project helped to establish the Quality Assurance Office at DP.

Summary

The experiences of the modular and credit-based curriculum and cooperative training developed and introduced at DP have convincingly proved that, within the conditions of mass education, it is suitable for preserving the quality and, in the case of elaboration of learning guidance methodologies, for improving it. We believe that this pilot program of model value can offer useful experiences for the development of Hungarian higher education.

Meanwhile, the Dunaujvaros and international experiences have also called attention to the fact that the introduction of the modularization and of the credit system is not merely the question of decision, but it is a thoroughly prepared activity that requires a definitely controlled development work lasting many years.

The new type of study materials (learning

guide, course textbooks/workbooks, self-evaluation/assessment tests, exercises, electronic study materials, open and distant learning materials, etc.), the alternative approach to the effective teaching-learning methods, the upgrading of the assessment and evaluation strategies, and the learning-centered, student-centered thinking itself require from the teachers the development of new skills instead of the customary traditional teaching activity. This can-

not be efficient without a total quality improvement circle of the teaching-learning process.

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Outcomes Assessment: A Pilot Study

By Bill Drake and Douglas Walcerz

Web-Based Continuous Outcomes Assessment: A Pilot Study

Outcomes assessment and continuous improvement are essential elements of educational programs. Emphasis on assessment is based primarily upon the requirements of accrediting agencies, but also on the perceived value of assessment in satisfying the demands for accountability in an increasingly competitive environment. Educational research has shown that measurement of educational outcomes can be used to inform an institution about educational goals that are being satisfied and those that are not. This information can motivate and

direct efforts to improve curricula.

In practice, the measurement of educational outcomes is challenging and can be expensive. Results are often ambiguous or statistically unsound. The positive impact of continuous improvement on the curriculum is difficult to prove (Allen, Noel, & Rienzi, 2000). Despite the difficulties and expense, accrediting groups and other agencies have mandated outcome assessment and continuous improvement. Of special note are new criteria by the Accreditation Board for Engineering and Technology (ABET). The new criteria rely

extensively on outcome assessment for accreditation, and there is a need for efficient and effective assessment processes to satisfy these requirements. These same outcomes are also applicable to many other programs, including those accredited by the National Association for Industrial Technology (NAIT), North Central Association of Colleges and Schools (NCA), and other accrediting groups. This article describes a pilot study of the implementation of a Web-based (TrueOutcomes©) assessment process in a technology program and examines the effectiveness of the process in terms of student and faculty buy-in and whether the process produces useful data and reports for accreditation and continuous improvement.

We qualitatively measured the following:

- Difficulty of learning the assessment process for instructors and students.
- Quality of the descriptions of educational experiences submitted by students.
- Ability of students to categorize their experiences according to educational outcomes.
- Usefulness and appropriateness of the assessment process and reports.

We quantitatively measured the level of participation of those students who participated.

TrueOutcomes (formerly EnableOA) is a Web-based, software-driven outcomes assessment process that was designed to be consistent with the nine *Principles of Good Practice for Assessing Student Learning*, an online publication by the American Association for Higher Education (AAHE, n.d.), and the *Program Evaluation Standards* developed by The Joint Committee on Standards for Educational Evaluation (1994).

The TrueOutcomes process (Walcerz, 1999a, 1999b) collects both descriptions of educational experiences that instructors intend for their students and descriptions of educational experiences that students perceive they have received from their instructional experiences. Instructors prepare the former and students develop the latter. Every outcome description is associated with one or more of the educational outcomes developed by the instructor. Students are encouraged to attach electronic copies of their actual work (e.g., reports, PowerPoint

presentations, CAD files, spreadsheets, programs, digital pictures of design projects, etc.) to support their descriptions. The outcome descriptions submitted by instructors are used to generate a matrix of coursework vs. educational outcomes that can be used in curriculum planning and evaluation. The descriptions that are submitted by students serve two primary purposes:

1. Students develop and maintain a personal electronic portfolio that serves as an extended resume and can be used for professional advancement. The usefulness of this extended electronic resume is the primary motivation for students to participate in the assessment process.
2. The descriptions are aggregated for a specific course or set of courses to see if students perceive and report the instructor's intended educational outcomes.

The Department of Industrial Management at Southwest Missouri State University (SMSU) offers a baccalaureate degree in industrial management (IM) with concentrations in construction and manufacturing management. The IM program enrolls about 300 students. The fall 2000 pilot study was conducted in two courses: Fundamentals of Engineering Drafting (TEC 110) and Industrial Safety (TEC 250). In the spring 2001, courses in Statics and Materials Testing were also piloted.

TEC 110 is a typical freshman-level drafting course in which CAD skills, sketching skills, and orthographic and isometric drawing techniques are practiced. TEC 250 is a sophomore-level course that meets one evening each week for three hours and is populated mainly by young adults with full-time jobs. The course emphasizes management of occupational safety programs.

Three accrediting agencies were associated with this study. Two directly impact SMSU and the third was included because of its impact on the development and application of the software.

Those agencies and their impact are briefly described here.

NAIT accredits the SMSU industrial technology program and has the following requirements with respect to assessment that are taken from the industrial technology accreditation handbook:

Assessment Plan and Integration: An assessment plan shall be comprised of, but not limited to, the following for each program: (1) program mission statement, (2) the desired program outcomes/student competencies, (3) evidence that the program incorporates these outcomes/student competencies, (4) the assessment measures used to evaluate

student mastery of the student competencies stated, (5) compilation of the results of the assessment measures, and (6) evidence that these results are used to improve the program. (NAIT, 2000, §§ 5.16 & 6.16)

NCA accredits SMSU as an institution and defines five criteria for accreditation and patterns of evidence to demonstrate the criteria. Statements relating to assessment are:

Criterion 3: The institution is accomplishing its educational and other purposes.

In determining appropriate patterns of evidence for this criterion, the Commission considers evidence such as:

. . . assessment of appropriate student academic achievement in all its programs, documenting: proficiency in skills and competencies essential for all college-educated adults; mastery of the level of knowledge appropriate to the degree granted; control by the institution's faculty of evaluation of student learning and granting of academic credit.

Criterion 4: The institution can continue to accomplish its purposes and strengthen its educational effectiveness. In determining appropriate patterns of evidence for this criterion, the Commission considers evidence such as:

. . . structured assessment processes that are continuous, that involve a variety of institutional constituencies, and that provide

meaningful and useful information to the planning processes as well as to students, faculty, and administration. (NCA, 2000, p. 9)

ABET has the following requirements with respect to assessment taken from criteria for accrediting engineering technology:

Programs must have written goals that, as a minimum, focus on the student body served, employer expectations, resource allocation, and other factors affecting the program. Programs are required to have plans for continuous improvement and evidence that the results are applied to further development and improvement of the program. Each program is required to demonstrate achievements through various methods including student outcomes assessment and employer feedback. Typical evidence may consist of student portfolios including project work and activity based learning; results of integrated curricula experiences; nationally-normed subject content examinations; recent graduate surveys that demonstrate graduate satisfaction with employment including career development activities, mobility opportunities, and appropriate job title; and employer surveys that demonstrate satisfaction with recent graduates. Programs also must demonstrate that their graduates are readily accepted into the workforce and are prepared for continuing education. (ABET, 2000, Criteria 1 & 6)

ABET developed and has introduced the following objectives as a part of Engineering Technology Criteria 2000 (ET2K). We believe that these objectives are compatible with the NAIT accreditation requirements. Since these outcomes were already developed and ready for use, they were adopted for this pilot study. The ABET objectives for graduates are:

1. Demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines.
2. Apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.
3. Conduct, analyze, and interpret experiments and apply experimental results to improve processes.

4. Apply creativity in the design of systems, components, or processes appropriate to program objectives.
5. Function effectively on teams.
6. Identify, analyze, and solve technical problems.
7. Communicate effectively.
8. Recognize the need for and possess the ability to pursue lifelong learning.
9. Understand professional, ethical, and social responsibilities.
10. Recognize contemporary professional, societal, and global issues and are aware of and respect diversity.
11. Have a commitment to quality, timeliness, and continuous improvement. (ABET, 2002)

In addition to NAIT and NCA, the state legislature, the State Coordinating Board for Higher Education, and the university administration all encourage verifiable assessment.

Implementation

Outcomes Assessment Solutions (formerly Enable Technologies), an application service provider, established an application Web site for SMSU on their Web server. Therefore, the institution did not need to buy hardware or software. Outcomes Assessment Solutions was provided with a spreadsheet containing the names of the courses, the instructor, and rosters of students participating in the pilot study. They then imported this information into the software to establish accounts for all the involved students and the instructor. The 11 pre-existing educational outcomes defined by ABET ET2K were also entered into the software.

Instructor intentions were composed for the fall courses, in consultation with Dr. Walcerz, the service provider representative. In the spring course, intentions were added independently by the instructor. The objectives intended for the students taking the courses were compared with the previously listed ABET-TAC standards. This exercise was found to be helpful in better defining course objectives. This process exposed intended outcomes that had not been well formulated and also revealed that course content was much broader in scope than was initially perceived.

Examples include:

- Intended outcome: Students will learn to utilize computer aided design (CAD) software. This matches Outcome 1: “Demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines.”
- Intended outcome: Students will develop sketching skills, which addresses this same standard.
- Intended outcome: Students will work in small groups to check each other’s drawings before final submission. This matches Outcome 5: “Function effectively in teams.”

The lack of submissions for last outcome emphasized that specific instruction in team building is needed for teamwork to be an outcome.

TEC 250, the industrial safety course, addressed different standards. In one instance we were able to take advantage of the global safety officer for General Electric fractional horsepower motor plants, who had just returned from a visit to a new manufacturing plant in India. We learned from her that their method for transferring concrete is significantly different than the concrete pumps we now find so familiar in the United States. In India women were engaged to transfer concrete by climbing ladders carrying the concrete, balanced in baskets, on their heads. This unintended consequence addressed the ET2K Outcome 8: “Recognize contemporary professional, societal, and global issues and are aware of and respect diversity.”

Working in groups to develop reports and requiring many brief written reaction papers addresses Outcome 7, “Communicate effectively,” as well as Outcome 5, “Function effectively on teams.” Communication with Blackboard software and associated e-mail techniques is another example accomplishing Outcome 1, “Mastering modern tools of their disciplines.”

The process of working through course objectives and comparing them to the outcomes yielded a much better appreciation of how the objectives fit into the overall scheme of developing, to use the campus vernacular, “an edu-

cated person.” The process of formulating these objectives and associating them with the ET2K standards initially took about one hour for each course. This involved reviewing the course syllabus and text(s) to identify what reasonable outcome objectives might be, creating instructor intended outcomes (word processing software recommended), and copying outcomes into the TrueOutcomes software.

Collecting Student Data

We presented the assessment software to students in two different ways. Because the TEC 110 class is a combination lab/lecture format, we were able to present the software to students as a laboratory exercise. After the first major test, the students were provided a set of instructions that directed them through help menus in the TrueOutcomes software. The students reported that these instructions were easy to follow and, after reading the introductory material, proceeded to make entries. Later analysis revealed that they were not all successful in making entries.

The same instructions used for TEC 110 were distributed to the TEC 250 class via e-mail and the Internet using Blackboard software. Later discussion with an informal sampling of students indicated that the TrueOutcomes “Help” process was easy to follow. However, analysis with the software indicated that only a little over 50% of the students successfully submitted entries. Speculation is that some students had failed to complete the submission process by missing a common last step . . . clicking the Submit Button.

Student Participation in the Assessment Process

A total of 37 students participated in the fall assessment process in two courses. Seventeen students submitted from one to three experiences to their electronic portfolios. In the software a color bar chart, Student Responses, provides data on student participation and indicates the percentage of students submitting experiences as well as the number submitted. In general, about one third of the students did not participate at all; one half submitted a single experience, and one sixth submitted multiple experiences. The apparent lack of participation may have been related to not clicking on the

Submit Button as entries were made. This theory is reinforced by the observation that the TEC 110 students who were observed in a lab exercise had lower overall participation than the TEC 250 class.

Quality Analysis of Student Narratives

In order to participate in the assessment process, students had to compose narrative statements of their classroom experiences, focusing on concrete descriptions of what they had done rather than conclusions about what they had learned. This cognitive engagement in the evaluation process is one of the most valuable attributes of this assessment system. A total of 26 narratives were submitted in the fall and analyzed for quality. Good narratives were written in first person, described the student’s work in good detail, and dealt with a single experience or a group of thematically related experiences. An example:

. . . a trip to the . . . plant and I got to observe first hand . . . safety and health procedures on the job. . . this trip it gave me a[n] understanding on what should be done in order to keep the company you work for safe, and this is what this class is all about understanding what it takes to keep the company you work for safe, so you don't have lost work days, have to pay workerman's [sic]comp, hire a replacement . . . and pay for overtime to catch up for the absents [sic] of a[n] employee. You need to have an understanding of safety and health, on the job, or it could cost the company a lot of money in hidden costs. With the tour . . . I saw a company with good safety procedures, in the employee's working environments . . .

Moderate narratives were written in first person, did not have enough detail, and sometimes included a collection of unrelated experiences. For example:

Recently we took a tour of a local manufacture[r]. I thought the trip was a good idea and very informative. I It [sic] was well worth the time to do so. It would be great if more such trips were possible.

Poor narratives were either too short (e.g., a

single 3-word phrase) or talked about what the student learned instead of what he or she did.

Example:

I feel that TEC 250 is a valuable course and all industrial technology majors should take it or something close to it. Safety should be a huge part in the industry, however it is not always a main priority. I think all managers should be trained in the safety arena.

An analysis of the students' narratives revealed 11 good quality narratives, 10 moderate narratives, and 4 poor narratives. The quality analysis of student narratives showed a substantial variation in quality between courses: TEC 250 had nearly 70% good quality narratives, while the TEC 110 class had nearly 70% medium to poor narratives. TEC 250 had more nontraditional students; therefore, student maturity would be expected to influence narrative quality. The software also provides a graphical display of the quality analysis.

For every experience students submitted, they selected the educational outcome that reflected their individual narrative. Our analysis showed that a majority of students selected too many outcomes; in other words, students selected outcomes such as "an ability to function on teams" when their narrative contained no mention of teamwork at all. A graphic showing Response Appropriateness is also provided. We found nearly 70% selected extraneous outcomes. Clearly more training in the use of the system is indicated. We believe this is consistent with the customary "mark sense" course evaluations where no active thought processes might be engaged. The cognitive engagement potential made available with this system could clearly provide some benefit in assessment.

The TrueOutcomes software automatically generates assessment reports based on the descriptions of experiences that students and instructors submit. A bar-chart presentation is available showing the percentage of students submitting experiences related to each of the 11 outcomes and the number of experiences related to that outcome. According to the data analysis, the percentage of students who perceived and reported at least one significant educational

experience demonstrating "an ability to communicate effectively," "an ability to function on teams," "an understanding of professional, ethical, and social responsibility," and "an ability to identify, analyze, and solve technical problems" was 53%, 42%, 42%, and 37%, respectively. If we only consider the students who participated in the assessment process, the percentages are 77%, 62%, 62%, and 54%, respectively. If the quality of the student narratives was moderate or good and the students were able to select appropriate outcomes, then it is patently clear evidence that TEC 250 is developing those four outcomes to a substantial degree and other outcomes to a lesser degree.

The software also allows an instructor to "drill into" any of the outcomes to read the student narratives, review the selected outcomes, view attached documents, and thus to check the validity of the data. As discussed previously, the quality of narratives in TEC 250 was quite good, but the selection of outcomes often included more than the narrative justified. However, the raw evidence, the student narratives and attached documentation, is available to the instructor for assessment purposes.

A standard matrix of technology courses vs. the outcomes they are designed to develop is also available. Across the top of the matrix are the 11 educational outcomes. Down the first column are listed all of the technology courses offered. The cells of the matrix are either blank, which means that the instructor does not intend to develop the associated outcome in that course, or else a 100%, which means that all of the students in the associated course have an instructor intending to develop the associated outcome. TrueOutcomes uses percentages instead of the more common "Xs" because some courses are not uniform across all sections and instructors. For example, one section may have an instructor who uses project teams, thus developing teamwork, while another section of the same course may have an instructor who does not. If there are 60 students in the former section and 40 in the latter, TrueOutcomes will report 60% in the cell associated with teamwork and that course.

When comparing experiences submitted by

students with experiences intended by the instructor, it was clear that the instructor's intentions were fulfilled with respect to the outcomes relating to teamwork, communication, and professional responsibility. The instructor's intentions were partially fulfilled with respect to outcomes relating to knowledge and tools, and commitment to quality. The intended outcomes of global issues and lifelong learning were not being well met. It is interesting to see that a large percentage of students reported developing problem solving, when this was not an intended outcome of the course. This initial analysis must be tempered by the knowledge that most students selected extraneous outcomes, so "drilling into" the reported experiences will be necessary to verify the results until students become more familiar with the process.

The ability to see what was happening as the term progresses is most intriguing. This "real time" access to student perceptions allows adjustments with current students as opposed to the standard end of term evaluation. This is preferable to having input that can only be applied to the next group of students. The fact that students have to be cognitively involved with this process also provides much better insight into evaluations.

Conclusions

The software and process were straightforward to learn and use for both the instructor and students. Student participation and the quality of student submissions were acceptable but not as good as desired. Analytical reports provide meaningful feedback and can be used to document the continuous improvement process for accreditation purposes. The process does not require an excessive time commitment on the part of the instructor. Students can access the software at their convenience in addition to the creation of a portfolio of personal achievements that may be of value in future endeavors.

The effort required to set up the TrueOutcomes program is balanced by the provision of in-depth insight into the educational process. That insight, into the way that activities engage students and address outcomes, provides new opportunity by emphasizing areas where improvements can be made.

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Electronic Course Delivery in Higher Education: Promise and Challenge

By John W. Sinn

Philosophical, political, quality, learning, and instructional challenges are being encountered as higher education institutions respond to pressures and enticements of the World Wide Web and the Internet. My involvement with electronic instruction, almost from the infancy of that process, provides a basis for my views on these challenges. I discuss these under four headings: In Higher Education, Teachers and Learners, Gifts of Electronic Instruction—A Review, and Ensuring Quality.

In Higher Education

Institutional policy, systems, and infrastructure developed over the years to support ongoing programs must change. Not only must traditional efforts be continued, but electronic instruction should be facilitated, governed, and integrated. In doing so, most ongoing activities exemplified by staff meetings, registration, bursar billings, or the bookstore will need to be changed as will virtually every activity of institutional life.

As the reach of instruction is extended outside the university walls, standards, systems, and policies will not only become linked via electronic means but will accommodate new modes of delivery. The university may also find that in order to deliver its instruction beyond its walls, it must understand and work within state, national, and even international laws. New issues of ownership and copyright and security of courses will require more and different sorts of attention and expertise in the new environment (Perley & Tanguay, 1999).

State Governing or Coordinating Boards

As with individual institutions, the state legislators and public higher education governing or controlling boards must consider their policies and attitudes of support or nonsupport for credit and courses offered out of state and the country by constituent universities. Such developments have implications for partnerships between institutions that are distant from one another, which may require state and possibly national government approval.

Many states support their higher education system on some sort of formula system that results in a subsidy to institutions. Electronic instruction introduces issues that need to be carefully and thoroughly investigated, understood, and planned for. There may be a danger in applying a formula used for traditional instruction to support electronic instruction. The flexibility of electronic instruction goes beyond consideration of changes within existing institutions. For example, implications for course loads, up or down, and how to address these in the electronic environment, along with many other questions about the role of faculty, must be assessed in various models. State governing agencies must give heed to the notion that new types of institutions and even entirely new state or proprietary university systems may be on the horizon. These may be based on paradigm shifts influenced by electronic instruction and yield, for example, creative ventures such as transfer credits among two- and four-year institutions, as well as high schools. Since electronic

delivery “levels the playing field,” in a geographic sense, playing in each other’s “back yard,” consortial arrangements among different institutions across regional, state, and even national boundaries become physically possible. One example of such an arrangement is the Indiana State University Technology Management Ph.D. Consortium. Involving several universities in various states, the consortium is primarily electronically delivered to focus on several specializations, including the quality systems specialization which the author has been engaged with (Sinn, 2002b).

The Individual University or College

Primarily residential campuses must become concerned with electronic courses, and their institutional mission should address non-traditional electronic delivery issues. The advent of electronic courses delivered anywhere poses serious questions about how to deal with and enable youth to mature and develop the social and intellectual skills that the undergraduate colleges have been providing. Thus, goals of institutions must continue to focus on attracting the best and brightest faculty and students, but also enable them to engage via electronic or traditional methods. The two approaches should not be considered exclusive of one another. On the other hand, blending them into a cohesive, effective university experience may not be a trivial matter. One approach for this is offered in learning communities for our future, both physical and electronic in nature.

Capital Resources

Another consequence of the electronic revolution is determining the flow of resources to affect the best use of bricks and mortar and the electronic infrastructure. Questions about whether buildings and, perhaps more important, the types of buildings that will be needed to support instruction in the future must be addressed.

In this regard, infrastructure shifts must be better anticipated, and future planning must enable rapid implementation and a speed-up of project implementation in order to accommodate the changes that will continue to happen quickly in electronic communications. Thus, institutional planners must acknowledge that

technology for electronic delivery will increasingly drive the process. Daniel (1997) noted this situation when he said:

We are engaged in a battle. The world’s universities are in a crisis, assailed by challenges of access, cost, and flexibility. The United States has the world’s strongest university system, and the world looks to it for leadership. Yet your system is wedded to teaching technologies that make it difficult for you to successfully respond to the crisis. (p. 17)

Daniel advocated a technology strategy to provide access and flexibility, but at the same time assure integrity in systems.

Hardware/Software

Hardware and software must be in place and configured to seamlessly enroll students in and start up an entire course via the Web. This process should be enabled from any location, without need to be on campus and without major intervention or inconvenience to student or faculty. Because of the importance of supporting courses, institutions need to ensure that servers for that purpose are separate from servers devoted to other administrative and e-mail uses. Doing so recognizes the “bread and butter” nature and appropriate stature of electronic teaching and learning.

Innovative models must be developed that offer faculty incentives to seek out and use new hardware and software delivery systems. Costs, convenience, conformity, and allowance for future change of hard and software must be balanced in light of higher education’s limited resources. Economies may be realized in shifts from bricks and mortar to virtual systems and merging traditional institutions and functions to reduce duplication. Other economies may be realized in leasing laptop systems rather than outright purchase and maintaining traditional labs with desktop technology. Costs of providing current desktop technologies per user must be determined and desktop setups reduced, enabling funds to be rolled over toward laptops. Doing this successfully will add flexibility inherent in laptops over the time and place-centered desktops (Waggoner, Sinn, Kennedy, Zargari, Corbett, 1997).

Teachers and Learners

Changes that may be observed in the university are primarily found in redefined roles in teaching and learning. These are reflected in changes in the “presence” of faculty that may occur through real physical presence or through a virtual or electronic presence. Students may become more self-reliant and autonomous, acquire knowledge differently, and be accountable in different ways. Course flexibility and configuration changes occur, and means of student, faculty, and course assessment become different.

Redefined Roles— Faculty as Instructors

Physical presence no longer means a professor standing in front of students to lecture or conduct other traditional classroom activities. The professor’s electronic presence is defined and accomplished by the use of various media such as digital documents, chats or video, or camera projection with audio.

Traditional teaching requires a physical presence and direct emotional involvement, whereas electronic delivery provides a detachment in discreet ways. Lectures, exams, structured meetings in one location, and other methods are basic traditions that we have come to accept as the “way things are to be done.” We are reminded that in a number of instances the traditional lecture was suggested as being one of the worst methods, despite the reality that most of us have relied heavily on this approach.

Electronic courses demand structure. Although planning and structure have been expected for teaching of traditional courses, it is possible to do a traditional lecture ill prepared and meandering, and even sometimes appear to be well prepared. Electronic instruction demands articulated and integrated preparation. The instructor’s presence is in fact the electronic configuration, and it is possible that in such courses the instructor will be able to work at home or in an office rather than in a classroom populated with students, each at his or her desk. Thus the instructor’s role becomes redefined. Faculty must organize and facilitate highly structured and orchestrated systems. They must rethink the entire teaching and learning processes.

Focus moves from the teacher as a lecturer at the center of attention to that of a facilitator and course designer, almost entirely focused on electronically delivered content and process.

Everything must be digitized or accessible via the Web, and what was done verbally and physically now must be formatted for students to download or interact with in some structured electronic manner. The goal is to have everything navigable in a fairly seamless and articulated manner by disciplined, computer literate learners. This is not a simple matter, and it may be resisted by faculty who dislike writing or who may not wish to carefully think through the design or redesign of a course.

Redefined Roles—Students as Autonomous Learners

Students become knowledge navigators, independently engaged, knowing when and how to “pick up the ball and run with it.” Traditions such as skipping classes, whiling away hours trivially, or using courses as social entrees do not apply in the electronic venue where students must navigate well-designed courses. Rather, they must be highly disciplined, focused, and goal oriented, able to work independently and in sometimes ambiguous and nebulous ways. Persons having difficulty working independently, or having a low tolerance for reading carefully and following structured, comprehensive instructions, may have difficulty in this intellectual environment. Properly designed electronic courses may cause those who really do not wish to be engaged intellectually to indicate dissatisfaction with the electronic environment, perhaps due to not being “spoon fed” as they may have been in the traditional classroom. On the other hand, highly motivated, computer literate learners can readily excel in the electronic environment.

Knowledge Acquisition

In Web courses, information and experience as content and process can be posted to provide a portfolio record of progress. Chat transcripts can be recorded and posted, along with conversations in e-mail. Disciplined growth of knowledge actually unfolds in courses, with powerful opportunities to assess teaching and learning, seamlessly documented as portfolios. As students do their work, it becomes streamed

together, step-by-step, to clearly show how the thought and intellectual process is formulated. While some may be uncomfortable with how “raw” this is, it cannot be denied that this “electronic dialogue” is the bottom line on when and how knowledge is grown.

Accountability and Assessment of Students, Faculty, and Courses

Traditional accountability systems are less applicable because students do not expect to take “pop quizzes.” Attendance taking is automated, and information is manipulated rapidly. Postings can be lost, and savvy computer users may be capable of “borrowing” materials not meant for them; thus, plagiarizing is a possibility. These can be defended against, as in traditional teaching, if the electronic course and systems of delivery are well thought out and changed periodically to correspond to learners’ needs and to technologies of delivery. Examinations and tests are dramatically different from the traditional classroom setting as is the entire system of accountability and assessment of the learner and the course. Nontraditional forms of documentation for assessment will become increasingly called upon for accountability of teams and individuals in courses as we diminish traditional forms of test taking based on traditional physical presence. For example, a team of students focused on a project may compile a portfolio of responses to address a technical problem at an industrial firm. The portfolio can document their progress, replacing traditional examinations.

Electronic courses can be rigorous, well designed, and structured. Robust team projects, with reality-based professional requirements, are very achievable in Web-based systems, perhaps even better configured in this way than in traditional courses. Engaging persons external to the academy can be achieved with use of a password. This enables projects and work where the world truly “becomes the lab.” Quality is readily measurable due primarily to the highly documented nature of the course in portfolio ways addressed and accessible as presented above. Further underpinnings and illustrations of innovative quality applications in nontraditional lab environments were provided by Olson and Sinn (1999) and Shipman and

Sinn (1997). It is suggested that the assessment of courses and instructional quality must become increasingly tied to the “deliverables” produced by students, illustrative of the capacity of the faculty to facilitate and empower emerging student talents, regardless of level, but particularly at the university. This also serves as an excellent illustration to demonstrate that the role of faculty, students, and the entire university is changing as a function of electronic design and delivery of courses.

Gifts of Electronic Instruction—A Review

Electronic delivery brings substantial flexibility and agility to courses that are virtually impossible in other instructional means. No longer do individuals need to be on campus or at the same location. People can be “hooked up” at home, work, virtually anywhere. Class meetings are more flexible in time, space, and location, but if included in a course, electronic chats require a common time and “room location” analogous to traditional time and place of traditional courses. All individuals involved will need properly configured computer systems, with laptops providing the greatest flexibility and agility. Classrooms and their buildings as we know them will decreasingly be required, which will cause serious challenges to institutional planners and administrators. Just as business and industry work innovatively, professional and general university preparation will be increasingly electronic, responding to customer demands for flexible, rapid-moving information.

Electronic delivery may actually enhance teaching and learning, and perhaps the basic criteria for electronic instruction should be how it will improve instructional effectiveness. With electronic instruction and learning, (a) teachers and learners should be better organized and more efficient; (b) teachers and learners should be more dynamic, flexible, and agile; and (c) quality assessment should be enhanced and evidenced more readily. The overall positive effects of electronic delivery may have a significant influence on the evolution of the discipline of technology (Sinn, 1998a).

Systems to connect and encourage research initiatives for “growing knowledge” electroni-

cally with our broader communities and customers as part of the academy must be explored. We must better analyze and identify learning attributes assumed prevalent in various levels and types of learners, relationship of maturity, and so on. If we can better understand learners' attributes or behaviors (Sinn 1997, 1998b) and electronic systems' attributes, perhaps we can better match the two with resultant improvement. Faculty and students may wish to be able to select courses and approaches to instruction as they discern what best suits their attributes and behaviors, disallowing those they may wish to avoid. All should be involved, required to experience change, gaining preparation electronically for the future, perhaps transparent, like any other instructional approach (Sinn, 2000).

Ensuring Quality

Assessment and evaluation are important as we determine value added or detracted by technology. Technology can provide opportunities to evaluate and assess traditional and electronic courses and systems. If infrastructure is in place, coursework built as portfolios can be communicated for accreditation, course evaluation by students and faculty, comparisons of electronic and traditional (same) courses, among others. It is possible to accredit, assess, and evaluate from a distance, rather than being on campus, if all are properly configured. As one important example, library resources provide significant institutional questions. Assuring that students have access to quality information beyond (but including) the Internet is key. Facilitating traditional print information available on campus for distance constituents fairly and equitably, engaging students and faculty in evaluating and using information from all sources, is the challenge.

Quality Systems

The existence of a quality system assures quality in electronic delivery. This necessitates a paradigm shift of significant proportions, beyond accreditation and assessment. But, if done properly, the quality system can address essential accreditation and assessment issues, and help build a robust environment for electronic delivery. A viable quality system will recognize the importance of faculty advising, student organization professional involvement, advisory committees, portfolios, alumni sur-

veys, cooperative education experiences, senior projects, and other internal and external mechanisms for assuring quality curriculum, all electronically (Sinn, 2002a).

Do we understand the European Union's role in the International Standards Organization (ISO) global drive for quality standards? What promise do the ISO quality drive (Lamprecht, 1992) globally, the Baldrige National Quality Award in America (National Institute of Standards and Technology, 2000), and other traditional quality issues such as Deming principles hold? A university-wide quality system can be the basis from which accreditation and assessment are conducted, all based on emerging standards and guidelines within the ISO context (American Society for Quality, 2000). The challenge may be to practice the Deming principle of placing responsibility for quality at the lowest level possible—in our environment faculty—to provide mechanisms for assessment and accreditation. As a quality system, this is a major paradigm shift that must occur organizationally in order to be competitive in the future. Quality systems must be at the curriculum and course level to achieve goals inherent in assessment and accreditation. Faculty must mesh directly with point of contact connected to our key customer, the student, in the quality system. Recent winners of the first Baldrige awards given in education underscore the depth and importance of the development of quality systems in education at all levels (Daniels, 2002).

Electronic accreditation is being developed by the Council for Higher Education Accreditation (CHEA) with the Western Governors University (WGU), designed to be used and tested at various institutions. Standards may be the same for all institutions, electronic and traditional, and they must be applied uniformly to all (CHEA, 1999). Additional insights were offered by Crow (1999) in an article in the *Chronicle of Higher Education*. While we may be vague on what the portfolio can do for the overall process, understanding quality suggests a very clear documentation role. Electronic portfolio documentation, driven curricularly by faculty, coupled with data collection, is a key mechanism required for quality, particularly for accreditation and assessment.

The Future

The primary recommendation is to pursue ongoing development of infrastructure and quality electronic delivery of courses. Fundamentally about change, the question is how to equip faculty, students, and staff to work electronically in a high quality manner. We must collectively re-think policy and standards for global quality systems and standards based on ISO and Baldrige quality criteria, as related to electronic delivery of courses. We must also acknowledge that this can greatly benefit our students, particularly by focusing on broad total quality systems institutionally, and link assessment, portfolios, and actual course evaluation and improvement through this quality system.

As a fundamental principle of quality, it is critical that we maintain courses similar to current departmental functions, placing ultimate responsibility for quality where it has always been, and should be, with faculty. This must occur simultaneously while the traditional department and faculty role will change dramatically, along with all that the university is about in the context of process, becoming increasingly electronic as well. Amidst all of the changes, the easy reaction of some may be to seize control of courses from faculty when, in fact, the technology and systems can and must facilitate empowerment.

In all that we do we must strive to improve hardware and software systems, relative to traditional systems, particularly courses and basic services. Technology improperly used can facilitate the addage "garbage in-garbage out," but it also offers many opportunities for improvement if we choose to develop infrastructure carefully and in detailed ways. This ought not be viewed as a trivial or simple task of implementation only, but must be carefully matched alongside faculty perceptions of what is critical to enhanced delivery of teaching and learning, particularly in a process context.

We must better anticipate and plan for change relating to electronic delivery. If we make substantial changes in one area, we will

see implications for other areas of our work and environment, and better strategic planning linking all aspects of our work and environment must be accounted for. As the customer base gradually shifts from being physical and present to electronic and virtual, the need for enhanced planning systems will be increasingly critical. This must begin with changes in how states perceive their role in the educational process, and consortial connections in broader infrastructure, globally, to take better advantage of collective resources and "best practices" at the local level.

As part of the change process, we must intentionally build increasingly robust models to optimize all that we are about via technologies of course delivery, relating how we work, growing human capital and knowledge, ongoing improvement systems to solve technical problems, and embracing classrooms well beyond traditional brick and mortar precepts and traditions. This must also include designing, structuring, and administering objective tests and experiments, as assessments, of both electronic and traditional teaching and learning scenarios to assist all in better understanding where and how to use all systems for best advantage.

Finally, changes should be done to improve all that we do, not simply for the sake of change. The immediate electronic delivery opportunities that beckon must be pursued, but only with careful and prudent consideration. This challenges us to objectively use our knowledge and experience to assess potential electronic delivery changes as positive and value adding. Change must occur, based on substantive evidence evolutionarily pointing toward improvements. Conventional wisdom suggests that electronic delivery, while not applicable to all we do, must be pursued for our future, but primarily based on evidence of improvement.

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Factors Influencing Participation in Technology Education Graduate Studies

By George E. Rogers and Phillip L. Cardon

Higher education has initiated a variety of educational reforms in an attempt to improve the effectiveness of teacher education over the last two decades. A major focus of the reform movement has been professionalization of schools that prepare educators. Metcalf-Turner and Fischetti (1996) indicated that traditional university approaches to teacher education were inadequate primarily because of disengagement between theory and practice. The need for context-rich educational experiences in teacher preparation is important in all teacher education, but is imperative in the field of technology education. Technology education demands a co-mingling of theory and principles with practice. Morris, Armstrong, and Price (1997) stated that the present teacher education system fails to equip preservice teachers for the realities of the classrooms they will enter. The challenge for technology teacher educators is to embrace reform initiatives that bridge pedagogy by encouraging the profession's best teachers to enter the teacher education faculty ranks, thus keeping technology teacher education theory current with classroom practice.

A key component of this educational reform is technology teacher education faculty versed in both practice and theory. To assist in facilitating these changes, Brown (2002) noted that 64% of the technology teacher education programs surveyed indicated that they would increase their faculty by one or more positions over the next five years. However, Brown also indicated that the field would be short an average of 25 qualified faculty candidates per year and that these positions could go unfilled. Without qualified technology teacher education faculty, it will be very difficult for these education reform efforts to succeed.

Graduate-level technology teacher education has not kept pace with the need for qualified faculty. The number of individuals pursuing graduate studies in technology education, focusing on teacher education, is at its lowest

level in five decades (Bell, 2001; Buffer, 1979; Erikson & McAlister, 1988). According to Brown (2002), the technology teacher education profession is in short supply of qualified faculty. Hill (2003) further noted that a shrinking pool of faculty is compromising leadership for the profession. Based on these trends, Volk (1997) predicted that "the demise of technology teacher preparation programs will occur around the year 2005" (p. 69).

Statement of the Problem

Since 1975, there has been a steady decrease in the number of technology teacher education graduates (Volk, 1997). This decrease has been compounded by a significant increase in the number of technology education teachers needed across the nation (Weston, 1997). A survey of technology education leaders rated insufficient quantities of technology education teachers and the elimination of technology teacher education programs at the university level as two of the most critical issues facing the profession (Wicklein, 1993).

Volk (1997) noted that one factor in the decline of university technology teacher education programs has been the lack of graduate-level prepared faculty to serve as technology teacher education professors. Buffer (1979) found that between 1955 and 1977 over 2,500 individuals received a doctoral degree with emphasis in industrial education, the predecessor of technology education. A survey of the *Industrial Teacher Education Directory* (Dennis, 1995, 1996; Bell, 1997, 1998, 1999, 2000) noted there were only 127 technology education doctoral degrees awarded between 1994 and 1999. Buffer (1979) further noted that there were 2,507 master's degrees awarded during the 1976-1977 academic year. This number pales in comparison to the 6,700 master's degrees awarded in 1938 (Buffer, 1979). Furthermore, an examination of the *Industrial Teacher Education Directory* indicated that only 209 master's degrees in technology education were earned in 1999.

Currently, there is a lack of information as to the causes in the decline in technology educators pursuing an advanced degree. Without increasing the number of graduate degrees in technology teacher education, the baccalaureate degree major of technology education may vanish and, consequently, technology education courses will no longer be provided to the nation's middle school and high school students. This research was an attempt to address one of the major problems facing the technology education profession: the lack of graduate prepared teacher education faculty.

Significance of the Problem

According to the International Technology Education Association (2000), technology education teachers prepare the nation's middle school and high school students with core technological knowledge and skills. Secondary technology education is a hands-on program of study that provides an opportunity for students to learn about communication, construction, design, manufacturing, power-energy, and transportation. Technological literacy benefits students from all fields, but especially those who choose technical careers, such as engineering, architecture, industrial design, manufacturing, and construction. Theoretically, a shortage of secondary technology education teachers could have an impact on the quality and quantity of students entering university engineering and technology programs.

The number of technology teacher education graduates from the nation's universities has reached a critical stage. As Volk (1997) noted, "if we do not address the issues, soon we will be going ... going ... gone" (p. 70). Volk further stated that "the corresponding decrease in doctoral degrees granted and diminished new professional opportunities in technology education teacher preparation programs does not afford the incentive or opportunity for new ideas to be promoted" (p. 69).

Purpose of the Study

The purpose of this research was to identify the factors that influence enrollment in technology teacher education graduate programs, both doctoral and master's levels. This study examined both positive factors, those that influence

technology education teachers to enroll in graduate education, and negative factors, barriers that deter teachers from entering either a doctoral or master's degree program. The following research questions were developed for examination:

1. What factors do graduate education program graduates identify as providing the greatest positive influence for their enrollment into a graduate program?
2. What factors do technology education teachers indicate would provide the greatest incentive to enroll in a graduate education program?
3. What factors do graduate education program graduates identify that provided the strongest barriers to their enrollment in a graduate program?
4. What factors do technology education teachers identify as providing the strongest barriers to their enrollment in a graduate education program?

Methodology

This study utilized a modified Delphi technique as noted by Paige, Dugger, and Wolansky (1996) and Wicklien (1993) to identify and analyze what factors led individuals to enter both doctoral programs and master's degree programs focusing on technology teacher education. Additionally, the factors that deter individuals from entering doctoral and master's degree programs were identified.

Population

Two pairs of Delphi panels were established: one pair for examination of the doctoral programs and the other pair of panels to study the master's degree programs. The first doctoral group consisted of recent doctoral graduates (1994 -1999) whose degrees were in technology education focusing on teacher education as indicated in the *Industrial Teacher Education Directory* (Dennis, 1995, 1996; Bell, 1997, 1998, 1999). The directory noted that 127 doctoral degrees were granted during this five-year timeframe. Institutions that had graduated five or more doctorates during the five-year time span were contacted and asked to provide the names and address of their technology education doctoral graduates. This resulted in a population of 15 doctoral graduates whose location could be

identified. These 15 individuals comprised the population for one panel of this modified Delphi study. From this population, nine doctoral graduates agreed to serve on the Delphi panel.

The second doctoral panel consisted of practicing technology education teachers. Technology education directors from six states were asked to identify five technology education teachers who currently hold a master's degree and whom the director would categorize as "an outstanding candidate for doctoral studies." This second doctoral population consisted of 30 technology education teachers having earned a master's degree and identified by their state director as a leader in the profession. From this population, 16 teachers agreed to serve on the Delphi panel.

The first master's degree panel consisted of technology education teachers who had earned a master's degree from 1994 through 1999. This panel was randomly drawn from an identified population of 209 technology education teachers who had earned a master's degree. From this sample, 19 teachers agreed to serve on the Delphi panel. The second master's degree panel consisted of 18 teachers without an advanced degree and who agreed to serve on the Delphi panel. These pre-master's program teachers were selected from a population of technology education teachers identified by state technology education directors.

Procedure

The first round of this modified Delphi study consisted of an open-ended survey mailed to all participants, doctoral graduates, master's degree graduates, and both sets of technology education teachers. Doctoral and master's degree graduates were asked to identify the factors that positively influenced their decision to enter and complete a graduate education program and to list those barriers that they were able to overcome in order to earn an advanced degree. The two non-advance degree panels were asked to list the factors that would positively influence them to enter either a doctoral program or a master's degree program. These two pairs of panels were also asked to identify the barriers that have deterred them from entering either a doctoral program or a master's degree program.

First round responses were then categorized into similar factor groupings for the second round review. Each panel's listings, doctoral graduates, master's degree graduates, and both sets of non-advance degree technology education teachers, were grouped into 10 common factors for both positive influences and barriers. Each Delphi panel was then mailed a set of second round instruments on which the participants were asked to rank-order the 10 factors from 1 (*greatest*) to 10 (*weakest*). Each participant received two ranking surveys, one noting positive influences and the other instrument listing barriers. The findings from the study's second round of responses were then compiled for a third Delphi round. Top rank-ordered items were selected to be used as the factors listed in the study's final round.

During the third and final Delphi round, participants were asked to rate each positive influence and each barrier on a 1 to 5 Likert-type scale (1 = *weak influence*, 3 = *absence of influence*, and 5 = *very strong influence*).

Findings

Master's degree graduates rated their personal goal and desire as the top influence for pursuing a graduate degree ($M = 4.74$, $SD = 0.56$; see Table 1), whereas technology education teachers without a master's degree rated their personal goal and desire at a lower level ($M = 4.00$, $SD = 1.14$). Doctoral graduates also rated their personal goals and desire as the top positive influence in enrolling and completing a doctoral program in technology education ($M = 4.63$, $SD = 0.70$; see Table 2). Technology education teachers from the doctoral Delphi panel who had completed a master's degree also noted that their personal goals and desire would provide them the most positive influence for entering a doctoral program ($M = 4.63$, $SD = 0.78$).

The university's geographical location was indicated as a positive influence by both master's degree graduates ($M = 4.37$, $SD = 0.68$) and their cohort of technology education teachers ($M = 4.28$, $SD = 1.02$). The positive influence of the university's location was also noted by the teachers with a master's degree from the doctoral panel ($M = 4.25$, $SD = 1.09$). However, the positive influence of geographical location was

not shared by doctoral graduates ($M = 2.38$, $SD = 1.58$). The difference in doctoral panel members with regard to the university's geographical location was also noted in the barriers section by the master's degree Delphi panelists (see Table 3). The pre-master's teachers rated the university's location as a significant barrier to enrolling in a master's degree program when compared to their master's degree graduate counterparts ($M = 3.50$, $SD = 1.58$; $M = 2.16$, $SD = 1.30$, respectively).

Doctoral graduates rated the doctoral program's quality and reputation along with its faculty's quality and reputation as positive influences ($M = 4.00$, $SD = 0.71$; $M = 4.00$, $SD = 0.87$). Technology education teachers, from the doctoral panel, rated the quality and reputation of the program and faculty lower ($M = 3.63$, SD

$= 0.70$; $M = 3.56$, $SD = 1.06$). Technology education teachers without a master's degree rated the quality and reputation of the university as their strongest positive influence ($M = 4.56$, $SD = 0.51$), whereas the master's degree graduates from this panel rated that item lower ($M = 3.84$, $SD = 1.01$).

Both groups from the doctoral Delphi panel indicated that time commitment was a substantial barrier that hindered their enrollment into a doctoral program ($M = 4.00$, $SD = 1.12$; $M = 4.38$, $SD = 0.86$; see Table 4). Both groups of technology education teachers from the master's degree panel also ranked time commitment as a barrier ($M = 3.58$, $SD = 1.35$; $M = 3.28$, $SD = 1.32$). Program residency requirements and a lack of quality programs did not appear to provide barriers to either pair of panels.

Table 1. Positive Influences for Enrolling in a Master's Program

Factor	Master's Graduates (n = 19)		Pre-Master's Teachers (n = 18)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Personal goal/desire	4.74	0.56	4.00	1.14
University's geographical location	4.37	0.68	4.28	1.02
Pay increase	4.05	1.27	4.22	0.73
Quality and reputation of university	3.84	1.01	4.56	0.51
Financial support/assistantships	2.26	1.59	3.17	1.65

Table 2. Positive Influences for Enrolling in a Doctoral Program

Factor	Doctoral Graduates (n = 9)		Non-Doctoral Teachers (n = 16)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Personal goal/desire	4.63	0.70	4.63	0.78
Financial support/assistantships	4.13	0.93	4.44	0.70
Quality and reputation of university	4.00	0.71	3.63	0.70
Quality and reputation of the faculty	4.00	0.87	3.56	1.06
Support of advisor/faculty	4.00	0.87	3.81	0.73
Support of family	4.00	1.22	4.38	0.60
Direct communication with advisor	3.88	1.05	3.81	0.81
Flexibility of the program	3.25	0.97	4.50	0.71
Interest in research	3.13	1.62	3.13	0.99
Credit for prior coursework	2.63	1.58	4.63	0.70
Short residency period	2.38	0.99	4.50	0.71
University's geographic location	2.38	1.58	4.25	1.09
Distance education offerings	1.63	0.99	4.25	1.20

Table 3. Barriers to Enrollment in a Master's Program

Factor	Master's Graduates (n = 19)		Pre-Master's Teachers (n = 18)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Time commitment	3.58	1.35	3.28	1.32
Financial	3.37	1.26	3.17	1.47
Lack of flexibility in the program	3.11	1.20	3.78	1.00
Lack of quality master's program	2.83	1.15	3.56	1.42
University's geographic location	2.16	1.30	3.50	1.58

Table 4. Barriers to Enrollment in a Doctoral Program

Factor	Doctoral Graduates (n = 9)		Non-Doctoral Teachers (n = 16)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Time commitment	4.00	1.12	4.38	0.86
Financial	3.75	0.97	3.81	0.88
Family responsibilities	3.50	1.22	4.38	0.70
Lack of flexibility in the program	3.38	1.73	3.44	1.41
Geographic location of university	3.00	1.22	3.88	1.50
Lack of quality doctoral programs	2.88	1.36	3.88	1.96
Program's residency requirement	2.75	1.09	3.69	1.45

Discussion

As with other studies using a modified Delphi technique (Clark & Wenig, 1999; Wicklein, 1993), discrepancies may occur in the gathering of data. During the process of this research, not all participants contributed to all three panels. Some respondents did not participate in the first panel but did participate in either the second or third round. However, their responses were deemed valuable and included in this research.

The purpose of this research was to determine the factors that influence or deter technology education teachers' decisions to enroll in graduate level technology teacher education programs. From the four questions, there were six influencing factors and two barriers that were ranked highest for influencing the decision of technology education teachers to enroll in graduate programs. The participants were in agreement as to the primary influencing factors.

According to the respondents, technology education teachers entering a doctoral program and graduates of both master's and doctoral programs identified their personal goals and desires

as the most important factor influencing them to enter or complete a graduate program. Pre-master's technology education teachers viewed their personal goals and desire to be a less important influencing factor. Although the university's geographical location was not rated highly as an influencing factor for doctoral graduates, it was very important for the other three groups. It should be noted that the pre-master's technology education teachers indicated that the quality and reputation of the university was influential in their decision to enter a master's program, whereas the doctoral graduates said the program and faculty quality and reputation were important for entering and completing a doctoral program.

The factor that was determined to be the strongest barrier to the enrollment of both pre-master's and master's technology education teachers in a master's degree program was the university geographical location. The second barrier that was shared by all four groups was the time commitment involved in a graduate program. It was interesting to note that program residency and the lack of quality programs were not determined to be barriers to enrollment, even though the doctoral graduates indicated the

program quality to be an important influencing factor in their decision to enroll.

Other factors influencing enrollment in technology teacher education graduate programs were also noted but were not as significant as those previously discussed. One factor indicated to influence pre-master's technology education teachers to enroll in a master's program was pay increase. Two factors that were determined to influence non-doctoral technology education teachers to enroll in a doctoral program included flexibility of the program and credit for prior course work.

There were several barriers to enrollment that did not have consensus from more than two groups but were significant. The pre-master's technology education teachers indicated that the lack of flexibility and lack of quality in master's programs were barriers to enrollment. Both doctoral panels indicated that family responsibilities and financial commitments were key barriers to their enrollment in a doctoral program.

In summary, it appears that several influencing factors and barriers are shared among several groups. The influencing factors include personal goals and desires and the university's geographical location. The barriers include the university geographical location and time commitment. While some of these factors are difficult to adjust, such as the university's geographic location, other factors such as personal goals and desires, time commitment, and program and faculty quality are flexible.

Recommendations

The information gained from this research is provided as a foundation for future research and program development. Through periodic evaluation of influencing factors and barriers to technology education teacher enrollment in graduate programs, the technology education field can make the necessary changes to improve program quality and increase enrollment.

Based on the information from this research, we recommend the following to graduate program coordinators:

1. Promote the quality of the university, the program, and its faculty. This can be

performed by integrating the *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association, 2000) into the program and encouraging faculty to become active in local, state, and national technology education organizations and conferences. Include information about the quality of the program in brochures and advertisements.

2. Capitalize on the technology education teacher's personal goals and desires to recruit qualified individuals into graduate education programs. When recruiting or interviewing, discuss the goals and desires of the teacher and indicate how your technology education graduate program can help the teacher fulfill those goals and desires.
3. Promote the location of the university and the cultural aspects of the community. Let the technology education teacher know that the program and university are in a great location for families, schools, spouse employment, etc.
4. Inform technology education teachers that time commitment is a requirement of graduate education and that there will be benefits to obtaining a graduate degree.

The following are recommendations for further study:

1. Periodic studies should be conducted to determine consistencies and changes to the influences and barriers indicated by technology education teachers regarding their enrollment in technology education graduate programs.
2. Research should be conducted to determine the factors that make a successful technology teacher education graduate program.

As noted by Paige et al. (1996),

doctoral-granting institutions must provide the leadership. This leadership must come in the form of providing programs that have a research focus directed toward contributing to the body of knowledge and

that are aimed at developing and providing future leaders with the background and experiences that are needed to move the profession forward into the 21st century. (p. 20)

If the universities do not increase their production of advanced degrees in technology education focusing on teacher education, Volk's (1997) doomsday prediction will be reality.

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Thinking About Technology Effects on Higher Education

By Mohammed F. Fahmy

Technology today extends over many fields and is very complicated in nature. Learning to “do” technology is an important way to understand and to learn what technology really means. In academia, this implies a needed change in our teaching methods and the design of new applied teaching methods to explain the processes resulting in the development of technology in the “real” world. Explanations of such processes are sought and are taught in new lab/classroom instructional settings that enhance the teaching of problem-solving skills. In a recent publication of the International Technology Education Association (ITEA, 2002), it was cited that “recent research on learning finds that many students learn best in experiential ways by doing, rather than only by seeing or hearing” (p. 5).

It is no wonder that in recent years a new wave of “experiential learning” has flooded academia. At the national level many universities, particularly publicly supported institutions, were required to develop and implement experiential learning methods across all of their disciplines and in their curricula. To encourage such practices, funds were made available from several state and federal sources. The resources allocated for this new methodology were, as usual, meager and not enough to achieve the stated goals. Some colleges, in pursuit of such funds, established what they called experiential learning classrooms as their main application of such newly encouraged teaching methods just to continue to benefit from the newly allocated funds. Continuous funding of these new experiential learning efforts to establish the infrastructure and to acquire needed equipment and hardware was, as usual, not adequately allocated or provided for, resulting in a long and laborious process in implementing such worthy efforts in academia. Students today not only need to learn how to do technology, they also need to learn how to live in today’s world, which has become one that is buzzing with information and misinformation. Students need to know how to col-

lect, sift through, and organize the information made available to them to augment and assess their own learning process. Ehrmann (1999) emphasized the value of technology by stating that “technology (in the broadest sense of that term) is providing a foundation for the reorganization of higher learning” (p. 42).

Technology and Change

To fully realize how technology and change are related, I will first define change and then discuss some factors such as need for change, importance of change, and resources needed to implement change in this section.

First what does *change* mean? The 1940 edition of the *Winston Dictionary* lists some of the definitions of the word change as: “to alter as, to change one’s habit; to vary; to undergo alteration; to pass from one place to another.” A more recent 1997 *Merriam-Webster Dictionary* cites some of the definitions of change as: “to make or become different, alter; to replace with another; ...etc; (n) the act, process, or result of changing; etc,” which is almost the same as that cited in the 1940 edition of the *Winston Dictionary* above.

Need for Change

Should we implement *every* new technological discovery in all professional fields once we know about it? Obviously the answer is no, we should not, at least until we understand the ramifications of such implementation. Next, what should we look for before even thinking of changing our established ways or procedures? Common sense necessitates that we should study the new technological phenomenon, decide whether it relates to our existing practices, and then study the possibility of its implementation. In other words, we must be sure that we understand the new technology and whether it would be a better fit of what we already have or not. Moreover, would it really benefit the organization if it is implemented? Or, at least be aware of the downside of its applications, especially if the new technology has not been studied and understood well enough yet.

Importance of Change

Once the new process, or technological phenomenon, has been carefully studied, we need to identify the areas and personnel that it will have direct impact on when fully implemented. Next, we need to convince those involved that the sought-after change will bring positive results both to the individual and general levels. In other words, explain why the organization will be in better shape and list the benefits, which will be brought about as a result of implementing this new technology or change. People can only be “champions of the cause” if they understand the consequences of its implementation on their personal lives and the organization as a whole.

Resources

Allocation of resources to bring about and to implement the new technology or practices is a very important and essential factor if any change is to be instituted. Such resources are needed for (a) feasibility and pilot studies; (b) training, re-training, or hiring of new trained personnel; (c) building the infrastructure (i.e., acquiring the new equipment or hardware needed for the full implementation of the new processes); and (d) continued assessment of the implementation of the process.

This factor (allocation of resources) could be viewed as the most important one in the process of change. Two sectors of our economy that might be viewed as the most successful in implementing new technologies because of readily available resources are *industry* and the *military*.

The military branch of the government, which may be viewed as the boldest in the implementation of new technologies, has proven to be at the forefront of technology applications. Its hierarchical structure and leadership structure—coupled with the generous resources made available for its development and annual operational cost, and other such factors as clear vision, willingness to try, ability to recognize value, impact on the success of mission, etc.—are believed to be the direct reasons as to why the military is way ahead of civilian organizations in the implementation of new technologies. The nature of the military as well as the

fact that the mere survival of its members depends vastly on the new applications mandates that it must be at the cutting edge of technology use and implementation.

On the other hand, many industries have realized that their own success and survival in a globally competitive arena depends greatly on their ability to implement new, relevant technologies to stay ahead of their competition, not only nationally, but also at the global level. Unlike the military, the industrial sector—even though it is willing to apply new technologies—is not as bold. There are other factors that private industry has to consider. At the forefront of such factors is the margin of profit. There has to be a very delicate balance between what the private sector is willing to spend on new technology applications and the margin of profit it has identified for itself to stay competitive. Another factor in the implementation of new technologies is the fear of the ramifications if the technology has not been fully understood yet. In the private sector, such failures may bring losses as a result of lawsuits and compensations for a failed product.

A third sector that may be involved in technology applications and the changes they bring about is the public sector, whose funding depends mainly on allocated funds by public institutions (e.g., local government, etc.). Public educational institutions fall under this category. Usually the progress such institutions achieve in the arena of technological applications and the changes they bring about is very slow compared to the other two sectors discussed above. The key factor here, again, is simply resources. Public academic institutions are, for the most part, governed by the resources made available to them more so than their ingenuity and willingness to implement new technologies. In their quest to apply new technologies needed for their ultimate survival and to stay competitive, public institutions are always compensated by meager allocations of funds controlled by their governing bodies. Such funds are often not enough to cover the needed changes. Many of these institutions, however, have stayed very close, if not at the cutting edge, by seeking external funds from a variety of sources such as other more fortunate government agencies (e.g., the mili-

tary, the National Science Foundation, the Department of Energy, etc.), industrial partnerships, or private foundations. The degree of success in finding external organizations willing to fund such efforts in higher education depends on many factors, including:

- Classification of the academic institution (land grant, research, comprehensive, etc.).
- Reputation of institution (public relations and marketing, previous dealings).
- Infrastructure of institution.
- Influence of institution on local or national government (pork monies allocations).
- Willingness of faculty and their ability to market their ideas and to make a convincing case for the funding organization to buy into their vision.

Recent Changes in Academe

Ehrmann (1999) described the three main revolutions that have taken place in education. The major transformation (or the first revolution) took place 2,500 years ago when the “oral exchange” between teachers and students was augmented by reading and writing. In his characterization, Ehrmann stated that “the rigidities of memorization were replaced by the even-stiffer rigidity of the written word and, later, the printed page” (p. 44). The second revolution, according to Ehrmann, started when students and teachers shared the same facilities (libraries, laboratories, etc.), which was the beginning of the educational community and campus life. This brought financial resources, not previously available, which caused the creation of a very complex environment (instructors, administrators, technicians, staff, students, publishers, etc.). The third revolution identified by Ehrmann is the one “made possible by computing, video, and telecommunication” (p. 42). One can safely term this third revolution as the technology revolution, which has brought about more learners and an inevitable change in the way higher education delivers its services. Even though this change is certain, its character “is not yet clear” (p. 46) according to Ehrmann.

The Future of Academe

What does the future hold for academe has

been the recent topic of many researchers and academicians. While there is not one single model that identifies clearly how all the researchers see the future of academe, there is a common vision of many of the anticipated elements of change. In the sections below, some of such elements are shared and discussed.

Technology and the Classroom

Carlson (2000) cited the issue of integrating technology with instruction as the single most important issue facing higher education. Other factors, which were identified in the same study as of less priority, were replacing outdated hardware or software, providing user support, providing online distance education, and integrating e-commerce into college and university Web sites and all other institutional services. While only 10% of college courses used electronic mail as a tool for instruction in 1994, Carlson cited that over 60% of courses in 2000 used this tool. According to him, 7% of courses had Web sites in 1994, whereas in 2000 the number was more than 30%. The report by the National Commission on the Cost of Higher Education (1998) concurred with these findings and noted that institutions were faced with the need to provide new equipment and infrastructure to accommodate this type of offerings. To meet the cost of such technology implementation, the report stated that institutions mandated computer/instructional technology fees ranging from \$55 to \$140 per student, hence passing some of such costs on to the students and their families. It is strongly believed that this trend will continue in the future to enable higher education institutions to update their classrooms and laboratories with the needed contemporary infrastructure required to deliver instruction to their students whether on campus or at a distance over newly established networks.

Other Technology Applications

According to Carlson (2000), academe is still lagging behind society at large in the application of some technology trends such as personal digital assistance devices (e.g., Palm Pilot) that campuses have not been able to integrate into their campus networks. E-commerce services is another area that shows academe far behind the private sector in application and use. Only 18.8% of the institutions surveyed, according to Carlson,

have set up e-commerce services (e.g., to pay tuition with credit cards) on their Web sites. The majority of colleges (80%) still do not see e-commerce applications as a service that should be allowed on campus Web sites. Like e-commerce, there are new e-learning companies such as Quisic 2000 (chronicle.quisic.com), which advertises that it believes that asking the right questions and learning new ways to answer them is essential. Further, the company claims to offer e-learning solutions for business education to help students and faculty achieve important goals. CollegeNet (www.corp.collegenet.com), another new e-company, has announced that its services are designed "to turn your school's homepage into an engine for web commerce as streamlining commerce with the new generation." Furthermore, Pelling (1997) and Kyrnin (2002) described a new technology, the "push technology," made available by the commercial Internet providers, as a phenomenon that is inevitable. Push technology describes efforts to make local information available to all users linked to the institution's network, hence pushing information to users rather than waiting for them to seek it. This way, push technology becomes a tool for educators to deliver instruction over a wider network.

As can be seen from the foregoing discussion, higher education institutions will be faced with more demands to cope with the fast-changing technologies and will be required to implement changes to accommodate such applications in order to deliver services in a manner that satisfies their clientele and to stay competitive at the same time.

Academe and the Information Society

Educators and society perceive the industrial revolution in general as a major reason for the shaping of our societies today. Many professionals and intellectuals believe a new revolution started recently, namely, the information/communication revolution, which will shape our future. This revolution in the exchange of information has been mainly caused by the great and rapid advances in technology. Levine (2000) identified new technologies as the major forces that have the power to change our university and college systems and the way they deliver their services as we know it

now. Other forces cited in his article were shifting demographics, the entrance of commercial organizations into higher education, the changing relationships between colleges and the federal and state governments, and the move from an industrial to an information society. He further listed nine major changes in higher education as inevitable changes that should not be ignored:

1. The creation of numerous and diverse "higher-education providers" that are global and more technologically advanced institutions. Such institutions will change the current practices and will necessitate a much faster response to an international student body, due to their ability to deliver instruction globally, if they are to stay successful and competitive.
2. The three types of higher education providers will be either brick universities (i.e., the traditional residential campus as we know it now), click universities currently known as virtual universities, or brick and click universities, which is a combination of both types that he predicts to be the most successful and competitive ones in the future. Gregory C. Farrington, president of Lehigh University, stated, "residential colleges might band together to share courses using the Internet" (as cited in Young, 2000, 1) to provide their students with highly specialized courses and hence cutting their cost of delivery. Ehrmann (1999) added to these shared efforts among universities online libraries so that physical and virtual campuses complement one another and provide more services to their "customers" at a much lower cost. As a result, new entities in higher education, consortia, partnerships, etc., will emerge.
3. More individualized higher education in which students set the educational agenda due to their diverse backgrounds. In this case, institutions will react to customer needs rather than setting the educational agenda as they traditionally have done. Education will be provided

wherever and whenever students decide to receive it: at home, in the office, in the car, or on campus. This will simply be achievable because of the new emerging technologies.

4. A shift of focus of higher education from teaching to learning. In other words, instead of a certain number of credits to measure student achievements, a competency-based education in which student outcomes are measured and assessed will be used.
5. The current triangle of teaching-scholarship-service that describes the activities of most of today's universities will become predominantly focused on teaching as dictated by for-profit and other new providers in higher education.
6. The creation of a new rock-star professor in which the name of the professor, not that of the institution, will be the most important in bringing in business for the university. In other words, professors will become increasingly more independent of colleges and universities. Young (2000) cited a new book that predicts that institutions will market lectures of their superstar professors and place them on a World Wide Web site, replacing outdated traditional lecture delivery.
7. Degrees will be replaced by a transcript in which students' competencies delineate the level of their skills and knowledge. Students no longer have to reside on any specific campus to obtain a degree; rather, they can move around and accumulate more recognized skills and competencies.
8. Educational portfolios, or "educational passports," will have to be created and maintained to identify students' achievements wherever and whenever they were gained.
9. Public and private support will be directed to students rather than to educational institutions.

Whether we agree that the future holds some or all of the above listed changes, many recent articles have listed many such changes in

the future of academe. Young (2000) cited a new book whose authors concluded that both technology and market forces can "improve university teaching, streamline offerings, and bring education to more students than ever" (p. 1).

Faculty Security and the Tenure Process

Another recent shift in higher education and university practices involves the process of tenure. Wilson (1998) discussed the issue of tenure and its future. He argued that colleges that have abolished the tenure process and now hire new faculty on an "annual contract" basis are increasing in numbers. He further stated that there are currently 40 institutions in the United States hiring professors on contract appointments, hence increasing the percentage of such institutions from 19% in 1979 to 28% in 1998. Even though such news is not readily announced, the phenomenon of hiring more adjunct professors has risen from 22% in 1970 to a new high of 42% and has attracted the attention of many educators. According to Wilson, this new trend will result in professors hired on contract to be either focused on teaching or research, but not both. He further explained that new titles of such professors will commonly be known as lecturers, research scientists, instructors, or clinical faculty and that they will not be considered voting faculty on many campuses. Changes in the tenure process have been long anticipated by many in academe. An overhaul of that process in the next few years will not surprise many at all.

Impact of Technology/Change on Other Areas of Academe

The impact of technology and the resulting changes on nonacademics of higher education is cited by Ault, Hainline, and Abunawass (1999). Areas and personnel affected by technology in academe include:

- Staff and the way they provide their services.
- Academic offices.
- Training of personnel and technicians and quality of performance.
- Bargaining and the changes in the workplace.
- Ability of institutions to "market" themselves.

Such areas that are impacted by the technological changes will, undoubtedly, need a process of re-evaluation so we can get the best services to the students who are, after all, impacted by all the services provided by or depending on the above listed areas.

Conclusion

Technology and technological applications are, indeed, a continuous process that dates way back in our human history. Every time a new technology comes around, a process of change accompanies its implementation. Higher education, like any other sector in our society, is affected by technology applications and always races to institute the necessary changes to implement it. As a matter of fact, many of the new technological applications were discovered and developed into prototypes, which were tested and modified on many campuses. However,

the full implementation, which needed resources beyond academe's reach, was always a long and laborious process.

If higher education and academe are to improve the rate of change that technological applications bring, they need to find new ways to fund such efforts. Educational institutions started to seek partnerships with industry, government, and the private sector as means of providing part or most of the costs associated with the implementation of such new technologies. It is believed that it is through such partnerships that the process of change will be accelerated better than it is today.

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Leadership Knowledge and Skill: An Enabler for Success as a Technology Education Teacher-Leader

By Robert E. Wenig

Introduction

While our technological society has rapidly moved into the digital-information age leadership has emerged as even more distinctive and essential for success (Reich, 2000). Experience teaches us that leadership can be exercised through noble uplifting pursuits or driven by corrupting repressive power. Leadership when positive creates a stimulating environment that builds a thriving organization but, when negative, it fosters a woe-fully oppressive and debilitation atmosphere which chokes performance. Historically, Americans love Washington, Jefferson, and Lincoln, but despised Hitler types who are autocratic tyrants. Research tells us that leaders are not born but emerge through a complex sociological process to satisfy some demanding need or want (Clark and Clark, 1996).

We are all familiar with the story of Winston Churchill, who during World War I was charged with poor military decisions ending in extensive loss of life. For nearly twenty years fame was derailed and influence ceased. Churchill referred to this time in his life as the wilderness years. Fortunately for England, Churchill took the advice of Benjamin Disraeli, who said, "The secret of success in life is for a man to be ready for his time when it comes." Certainly, it was Churchill's time when he was elected Prime Minister of England in 1939 at the beginning of WW II. He more than anyone else rallied the English people through inspiring speeches and endless work to achieve eventual victory. Today, England, and others, consider Churchill, the greatest Englishman who ever lived. Similarly, great teachers rise to the challenge by becoming successful classroom leader through a combination of ever increasing knowledge and elevating experiences (Walling, 1994).

Purpose

The purpose of this article is to share the value of leadership knowledge and skill for enhancing the survival and performance of teachers and leaders.

Leadership and Performance

When performance of an individual, organization, or event is discussed leadership becomes the dominant subject. Recently a cartoon appeared in the Wall Street Journal where two men were having a heated discussion about leadership. Finally, one turned to the other and said, "Yes, we need leadership, but also we need someone to tell us what to do." Most people have difficulty attempting to understand or appropriately use leadership (Peters, 1992 and Drucker, 1993). They see it as hazy, confusing, or a distant abstraction.

Nevertheless, most people can comprehend the behaviors of great leaders and teachers when they can personally relate to their actions. Let me illustrate. Recently I visited an art museum displaying works of some of the world's most famous artists. There were paintings by Monet, Picasso, van Gogh, Renoir and many others on display. The paintings I enjoyed the most were those that gave a clear depiction of something I am familiar with, such as a serene lake, a gathering of flowers, or people easily recognized as humans. There were other paintings on display that portrayed distorted figures, and blurred shapes and colors that defy description. Certainly, these too, are valued works of art that were carefully selected to represent the variety of creative expression, but the distant abstraction left me with a feeling of emptiness or even confusion. Similarly, the omnipotence or great secret of highly effective leaders and teachers is achieved when they cut confusion and haziness to relate and build understanding. An example of transforming from a hazy-confusing leaderless environment to a clearly functioning leadership process can be found in the small book, *The Leaders Compass* (2003) by Ruggero and Hailey. This is a must read by the beginning leader.

Clark and Clark, (1997) state, that with effective leadership any organization can increase its performance by at least 20-25 percent. Further, educational literature suggests that

an effective teacher-leader can also raise the learning level of his/her students by 15-25 percent. Accordingly, the relationship between gifted teachers and gifted leaders is very similar as Williams (2001) found in her dissertation that compared award winning local school technology teachers and their use of effective leadership practices. Hasting, (1991) agreed in her article, *Teachers as Leaders* saying, “teachers as leaders model the way or influencing their students to follow” (p.24.).

Leadership Defined

Bennis and Nanus, (1985), stated in their award winning book, *Leaders*, “Decades of academic analysis have given more than 350 definitions of leadership”(p. 4). Even today, the quest continues to specifically define just what is leadership. One stirring and profound definition of leadership that is well accepted by noted experts is Burns’ (1978) “transformational leadership” which is described in his classic and award winning book, *Leadership*. He defined a transformational leader as one who creates a vigorous and magnetic environment in which the leader and his/her followers raise each other to higher and higher levels of motivation and morality.

It happens when a leader can harness and focus an organizational member’s energy into a collective force resulting in a powerful empowering process that transforms both the individual and organization to higher and higher levels of performance. The best leadership thinking today (Covey, 1992; Kanter, 2001; Kotter, 1996; Reich, 2001; Senge et. al, 1999) about how to gain the highest level of organizational performance continues to include a leader who successfully uses transformational leadership. Again, transformational leader-teacher creates an environment that releases human potential then reinforces it by giving recognition and the opportunities for continuous personal growth (Walling, 1994; & Wenig, 1995).

Finally, after years of concerned involvement in leadership theory and application, I believe that it is more important to define leadership by what it “does” rather than by what it “is”. At first glance, what a transformational leader does seems so simple, yet it possess that

overwhelming powerful human propellant called “hope”. Accordingly, top leaders and teachers are a “merchant of hope” those who elevate the meaning and aspiration of others to form an organization under pinned by hope. Hope can be germinated by leaders-teachers who propel others-students to rise to higher and higher levels of success. Leadership then, when practiced at its positive best, produces hope, that propels individuals and organizations that transform dreams into visions and visions into actions - - “a vision community” (Barker, 1994). The leader-teacher who applies the powerful spirit and tenor of “hope”, establishes transformational leadership in the classroom/boardroom, the magical key ingredient to gaining a dynamic and fruitful future for all involved. Debbie Kennedy, (June, 1991) perhaps expresses the significance of hope in the following poem titled, “Our Dreams In Action”:

Dreams give us hope.

Hope ignites passion.

Passion leads us to envision success.

Recognition of opportunities inspires far-reaching possibilities

Far-reaching possibilities help us enlist support from others.

Support from others keeps us focused and committed.

Focus and commitment foster action.

Action results in progress.

Progress leads to achievement.

Achievement inspires dreams.

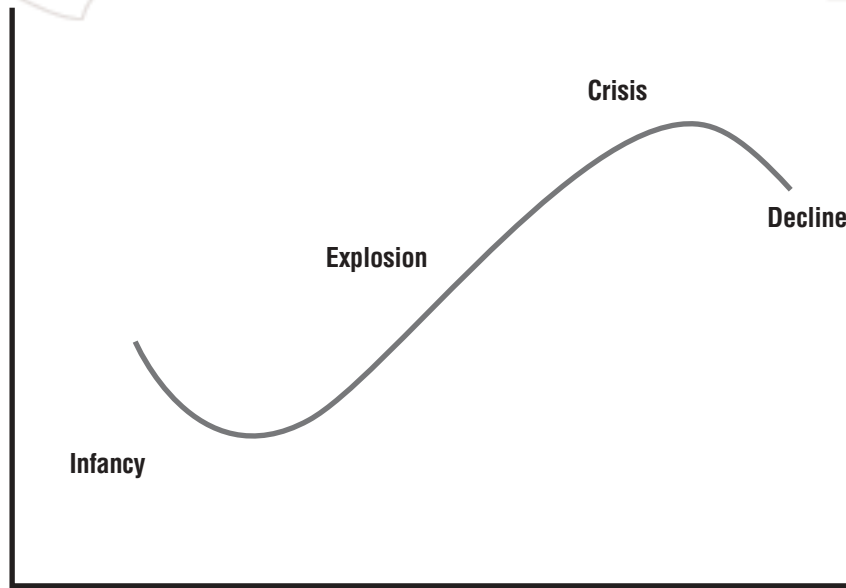
Dreams give us hope.

Perhaps Warren Bennis (2003 & 2003) ship expert, stated it best about *hope* when he stated, leadership involves creating larger visions and engaging people’s imagination in pursuit of them.

Leadership Knowledge for Survival

Rip Van Winkle went to sleep for twenty years. When he awakened, the American landscape had changed dramatically, and his bones creaked with age. The world around him was no longer one he understood or in which he could function well. Will history someday see that

Figure 1. The “S” Curve: The Life Cycle of An Organization.



classic story as a parable for leadership in American public and private organizations? George Santayana, the noted anthropologist, once observed that in our changing world we no longer salute our ancestors but bid them farewell. The world constantly searches for new knowledge and wisdom to answer very complex problems with simplicity. Let me illustrate. There is old parable about the grasshopper that decided to consult the hoary consultant of the animal kingdom, the owl, about a personal problem. The problems concerned the fact that the grasshopper suffered each winter from severe pains due to the savage temperature. After a number of these painful winters, in which all of the grasshopper's known remedies were of no avail, he presented his case to the venerable and wise owl. The owl, after patiently listening to the grasshopper's misery, so the story goes prescribed a simple solution. Simply turn your self into a cricket, and hibernate during the winter." The grasshopper jumped joyously away, profusely thanking the owl for his wise advice. Later, however, after discovering that this important knowledge could not be transformed into action, the grasshopper returned to the owl and asked how he could perform this metamorphosis. The owl replied rather curtly, "Look, I gave you the principle, it's up to you to work out the details!"

All parables, supposedly, contain a moral, and the moral here is that even if knowledge is provided survival is linked to actually performing the metamorphous. Again, transformational leadership elevates performance of individuals from the boardroom to the classroom. Leadership knowledge is paramount to change (Kotter, 1996), and change is the key to organizational survival (Senge, 1999).

The present-day "S" Curve (see Figure 1) evolved in the early part of the twenty-century from the work of Russian economist Nikolai Kondratieff and was popularized in America by Joseph Schumpeter in 1939. It represents the typical life cycle of an organization that last beyond infancy. Through dynamic and creative leadership, the opportunity for an organization to experience explosive growth is possible. However, over time things change; competition increases, cost rises, new technology suddenly appears, economic down-turn occurs, product demand falls, management falters, or whatever happens to trigger decline eventually ending in failure. When reviewing super successful surviving organizations (e.g., Ford, IBM, Johnson and Johnson, and 3 M) one finds a core ideology of visionary leadership one that has a passion for learning to stay competitive. Accordingly, organizations that are built to last (Collins & Porras, 1997) feverously keep

informed (knowledgeable) about the future which enables them to constantly plan and execute critical intervention strategies (see Figure 2) at key times to avoid stagnation and decline to propel continuous rebirth and growth.

There is a significant example of not staying competitive (realizing the “S” Curve) as found in American public schools. The word competition was foreign to the public educational system. Many thought that no outside force could or would attempt to provide K-12 education. Over time, public schools failed to implement key intervention strategies to meet their greatest challenge parent dissatisfaction with public school performance. Certainly, lack of parent confidence has triggered the advent of home schooling, charter schools, vouchers, and yes, even private businesses schooling children. All are pursuing a replacement to the traditional public school system.

Research has consistently said that the difference between model and poorly run schools is the “Whoever be chief among you let him be your servant principal’s leadership performance (Clark and Clark, 1997). It is obvious that TED can significantly benefit from possessing leadership knowledge and skills because the future belongs to the informed (Collins & Porras, 1997 & Peters, 1994). In time of drastic change, the learners inherit the future. The learned find them equipped to live in a world that no longer exists (Reich, 2001 & Senge et. al., 1999).

Finally, Servant-Teacher-Leader

Historically, the Bible reveals through endless stories examples of individual servant leadership, especially those in the New Testament. In 1966, Queen Elizabeth II, the present Queen of England, placed a large carved plaque in Westminster Abby which stated, “Whoever be chief among you let him be your servant.” “The term servant-leadership was first coined in the United States in a 1977 essay by Robert K. Greenleaf entitled, *The Servant First Leader* (Spears, 1995 P.2) Question. If the leader’s overwhelming desire is to serve when or how does the leader lead? Leading and Serving seems rather contradictory, or is it? Another perplexing question, does a leader lead first by serving or serving first then lead? To answer these ques-

tions, Greenleaf wrote:

“Servant-leader begins with the natural feeling that one wants to serve, to serve first. Then conscious choice brings one to aspire to lead. The difference manifests itself in the care taken by the servant—first to make sure that other people’s highest-priority needs are being served. The best test is: Do those served grow as persons; do they, while being served, become healthier, wiser, freer, more autonomous, more likely themselves to become servants? ...At the core, servant-leadership is a long-term, transformational approach to life and work...a way of being that has the potential to create positive change throughout our society” (Spears 1995, p.4).

Greenleaf went on to say, “When I started to write on the servant-leader theme, I was trying to communicate a basis of [hope]—not just for students but for everybody” (Spears, 1995 p.21). Hope or servant-leadership, then, provides a most powerful pronouncement again for the operational behavior followed by the best teachers and leaders.

Historically, we have some understanding of where the idea of servant came from, but what triggered Greenleaf to add servant to leader or leadership? Greenleaf (1984) stated that he conceptualizes and coined the term servant-leadership after Eventually; he comes to realize that it was his servant, Leo, who held him and his group together. After many years of wondering, the director finds Leo again, who as it turns out, is the head of the spiritual community that the director was seeking all along. Reading on it becomes more and more clear that the director is actually Hesse, himself, an autobiographical character. After Hesse (A Nobel Prize for Literature in 1946) was initiated in the spiritual order Leo and Hesse are talking and they are holding a small transparent sculpture of two figures joined together. One is Leo and other is Hesse who realized that his image was in the process of adding and flowing into Leo’s nourishment and strengthening. Reading the story about Hermann Hesse’s (1956-2003) *Journal to the East*. The story is about a party of seekers searching for enlightenment in the

form of a particular secret spiritual order. Leo, a servant, attends to their needs and does menial chores. Throughout the journey, the group is sustained by Leo's "spirit and his song." Leo eventually disappears. The party gets completely lost and gives up on the search. The party director carries on but suffers immense emotional and physical stress.

Peter Senge (1995), after reading the *Journey to the East*, "I knew that this man [Greenleaf] understood something, something we have lost in our modern transactional society, where 'what's in it for me' is the assumed bedrock of all actions." To make it very clear, servant-teacher-leader grand design focuses on serving others by adding and flowing together to achieve one image using nourishment and strength. Robert Frost said, "All great things are done for their sake." Senge adds, to think that this reorientation of spirit might be a foundation for true leadership stunned me.

The significance of the servant-leadership concept has led to the establishment of the Robert K. Greenleaf Center for Servant-Leadership. Further, the 1995 publication, *Reflections on Leadership* also includes the writings of Greenleaf with companion reflections about Greenleaf works. The importance of the Greenleaf's was given further credence in the "Indianapolis Business Journal" which stated, "Servant leadership has emerged as one of the dominant philosophies being discussed in the world today (Spears, L. C, *Reflections on Leadership* 1995).

Summary

History has shown us that leadership can

either be positive or negative. When positive and of the highest quality it can enhance performance, whether in the classroom or boardroom, remarkably by 20-25%. The master teacher who seems to draw us out has thrilled us all. These same high qualities are also found in top leaders. The teacher-leader makes a difference—a big difference for they model the way to influence our lives. Through an examination of the literature and research, the author attempts to discover what makes leadership such a powerful force. The first research question dealt with how to gain and inspire support. The challenges and possible opportunities facing TED are also discussed.. Second question reviewed the research on effective TED teaching. The findings indicated that innovative teachers are professionally involved in their associations, have greater school support, use different instructional methods and are very creative.

The third research question provided information on how TED could apply the dynamics of leadership to sell its benefits. These processes include: developing communication power, applying various leadership development models, bringing about effective change, using visioning technology to set the course, and the need of research to apply the teacher-leader model for developing Technology Education for American youth.

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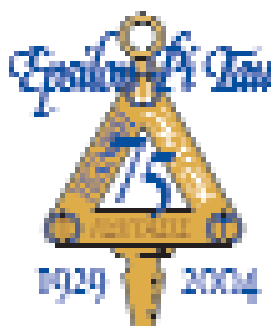
The Journal of Technology Studies

On-line Edition

Volume XXX, Number 2

Spring 2004

**Promoting Excellence in Preparation
and Excellence in Practice**



A refereed publication of

Epsilon Pi Tau

The International Honor Society for Professions in Technology

The Journal of Technology Studies

A refereed publication of *Epsilon Pi Tau* The International Honor Society for Professions in Technology.

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The Journal of Technology Studies (JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc, a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0305. Use this address or jots@bgnet.bgsu.edu for subscription matters or purchases.

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Two print issues per year are mailed to all members of the society and to academic and general libraries around the globe. Issues that are published on-line only, the aforementioned printed issues, and past issues are available free online at scholar.lib.vt.edu/ejournals/JTS.

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Separate articles or complete issues are also available in a variety of media forms from:

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Printed in the United States of America by Kennedy Printing Company, Findlay Ohio.

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Articles

Learning & Growing: Integrating Technology Undergraduates into the Development of an Industrial Case Study

Kathryne Newton and Edie Schmidt

A national industrial distribution association approached us to develop a case study for its association members. The national association assumed responsibility for identifying educational needs of upper level, mid level, and lower level personnel in the industry. In the previous year, a case study had been developed to educate upper level managers in the strategic nature of distribution in their industry. The association found that upper level management had a great learning experience and wanted lower level workers to have the same opportunity to refine and enhance their knowledge on making inventory and warehousing decisions. The project objective was to develop a case study that would be used in a weekend workshop to educate operations and customer service personnel involved in making logistics-related decisions. The mid level operations and customer service personnel were to attend a two-day workshop to learn basic terminology, analyze the case study, and refine their current knowledge surrounding their job duties.

This article describes the process of developing a case study for a national trade association and integrating learning opportunities for undergraduate technology students at Purdue University. The needs assessment phase of this project became an Inventory and Warehouse Management course project. The educational goal for the weekend industrial workshop, based on the case study, was to accomplish the following:

- Be valuable for companies with \$5 million to \$400 million in sales.
- Address the environment where employees typically handle 3,000 to 8,000 stock-keeping units.
- Teach the attendees in a highly participative setting.
- Incorporate small group activities.

The educational materials to be developed for the weekend workshop were a new case study, workbook, supporting reading materials, PowerPoint presentation, glossary of common terms, and an evaluation instrument.

The topic areas to be covered in the case study and the weekend workshop were:

- Inventory management and control.
- Product backorder and returned goods.
- Facility selection and layout.
- New product introduction.
- Order fulfillment routines.
- Selection of transportation modes.
- Multiple branch issues.
- New technology adoption.
- Human resource management.
- Key productivity measures.
- International issues.

Background on Educational Component

One of the first steps in the case study development (to be described more completely under the methodology section) was to research the needs of the trade association members. The students accomplished this by developing and analyzing results of a survey administered to the industrial distribution trade association members regarding their logistics and operational educational needs. This task proved a valuable opportunity to integrate the project with a scheduled junior-level class at Purdue University in the School of Technology. The School of Technology (and the Industrial Technology Department) prides itself on teaching students applied concepts via hands-on learning, experiential exercises. Just as important is the need to address what Savage (2001) called “the challenge of dealing with the ‘Moving Target’ of Technology” (p. 9). Faculty must be committed to providing opportunities for relevant content in “learner contemporary” concepts and providing challenging coursework for students. What better chance to teach the concepts and topic areas identified earlier than having the Inventory and Warehouse Management students apply what they learn in the class to this project? The course content covered all topic areas necessary for the case study workshop, which made the case study development a great learning and teaching opportunity.

Faculty and students have evolved to the point where they value learning through interactive assignments. The objective of this project was to enhance students' learning through increasing knowledge in the following three areas: (a) systems knowledge; (b) topical areas such as inventory management, facility layout, product backorders, and other topical areas identified earlier for companies hiring industrial technology students; and c) reflectivity, which involves comparing one's thinking to experts and peers.

If students are to develop systems understanding, then they must engage in all aspects of the system, which includes elements, relationships among elements, operations that describe how the elements interact, and patterns or rules that govern the preceding relationships and operations (Lesh & Kelly, 2000). For example, topics in the Inventory and Warehouse Management class include new product introduction, order fulfillment, selection of transportation modes, new technology adoption, and so on. Each topic listed above is in itself a subsystem. These subsystems comprise the industrial distribution and manufacturing system.

Each topic must be understood along with the relationships to other topics and the rules and patterns that govern the complex industrial organization. By mapping out the needs of industrial distributors in several topic areas, students are able to attain systems knowledge of distribution topics.

The Society of Manufacturing Engineers (1999) worked with industry and colleges and universities to analyze the skills and knowledge necessary for college graduates to become effective workers in the manufacturing industry. The study identified 15 competency gaps including:

- Problem-solving abilities.
- Fundamental topic knowledge such as manufacturing systems, logistics, and product/process design.

This project gave students an opportunity to delve deeper into these topics by applying course topics and learning additional information about distributors' problems and issues.

Another learning objective of coursework is the ability to think reflectively, where reflective thinking involves actively monitoring, evaluating, and modifying one's thinking and comparing it to both expert models and peers (Lin, Hmelo, Kinzer, & Secules, 1999). This project gave students a chance to compare their beliefs about current issues in warehouse and inventory with distributor beliefs on the same issues.

Methodology

Case studies are valuable learning tools because the case study describes a real situation for learners. According to Smith and Ragan (1999), case studies are similar to simulations in that they present a realistic situation and require learners to respond as if they were responsible for solving the problem. "Case studies also require learners to select and manipulate multiple principles in order to solve problems" (Smith & Ragan, 1999, p. 145). In order to make this case study "real" to the inventory and warehouse personnel, the case study materials were developed using these four main steps:

1. Research the needs of the trade association members, with undergraduate Purdue students assisting faculty.
2. Establish an overall model for the case study.
3. Evaluate the case study first draft with assistance of association board members.
4. Finalize the case study and develop the supporting educational materials.

Step 1: Research the Needs of the Trade Association Members

The students had an opportunity to apply what they learned in class by developing a survey instrument to be administered to trade association industrial distribution members. The students were assigned a semester-long group project, with four students per group.

- The 1. Develop a list of questions for three topic areas from the suggested list above (inventory management and control, productivity, etc.).
2. Contact two distributors and document the results of their responses.
3. Generate a written report.
4. Present recommendations and suggestions to the class.

Each student group was asked to pick three topic areas from the list of topic areas to be covered in the case study. The students developed a list of questions to ask distributor personnel related to the topic area. The questions captured the information needed for the study. In order to validate the questions, the students individually assessed the questions and responded to the question to determine the types of responses to expect. Then, as a student group, the questions and responses were analyzed. Were the answers valuable? Were responses inconsistent? (i.e., Did one person respond completely differently from another person?), or Was the question unclear? Problem areas for each of the questions were then identified. The student groups then finalized questions with tables of responses expected from the distributors.

Example for topic area: Backorders and Returned Goods

Question: What is your policy for handling product backorders?

Answer 1: The backorders are filled as early as possible.

Answer 2: What is a backorder?

Answer 3: Backorders are filled before new orders are filled.

The students determined that different respondents might see each question uniquely different, so identifying some specific problems with the questions was necessary. Continuing on with this example, the students identified these problem areas for the backorder and returned goods topic area:

1. What is meant by backorders?
2. Is the prioritization of backorders the key?
3. The term policy is ambiguous.

The problem areas then forced the members of the student group to reevaluate their objective in asking the question and develop a more complete question. In this case the student group determined the following question would capture the essence of the information they were seeking:

When your company has an order that cannot be filled immediately from on-hand inventory, how do you make sure the customer gets its order?

The output from each student group was a survey customized for three topic areas. The trade association then gave the students a list of distributors to contact, and the students began the process of contacting the distributors via email and fax.

The student groups were responsible for contacting three to five distributors each and documenting the distributor responses by organizing the data in tables and charts. These results clearly identified key issues and problem areas for the distributors' case study and also statistics for most common responses and unusual responses. Another benefit from the results was the discovery of special jargon and terminology used in the industry. The students collected data from over 40 distributors, with at least four distributor respondents per topic area. For each topic area, the students aggregated the differences and similarities of responses. These similarities and differences in operating procedure were highlighted by size of company, product type, number of stockkeeping units, and location. This information gave an even clearer picture of the audience for the weekend workshop.

The data collection process was not over yet, however. We then visited distributor warehouses in the industry to further validate the survey results. On-site visits with different-sized distributors were particularly valuable for verification of the issues from the distributor survey responses. Although the distributors were in the same industry, each was unique in how it conducted business, the knowledge level of warehouse personnel, and terminology used by each employee. Lastly, these site visits confirmed that the workshop would have to be conducted at a level consistent with the typical warehouse and inventory personnel education and experience level. Given the varied backgrounds of the personnel, the workshop was developed using adult learning principles. Characteristics of adult learners are (a) their experience is a foundation for learning but each adult learner is unique in his/her needs because of age, ability, work experience, and cultural background, and (b) adult learners expect class time to be well spent and help

them immediately apply their knowledge to their daily lives (Wisma, 2001).

Step 2: Establish an Overall Model of the Case Study

The data collection site visit phase identified key competencies and areas for improvement for distributors in the industry. The six-page case study incorporated the human element with main characters the inventory and warehouse personnel would relate to, as well as key problems likely to be experienced in each company. The case was a scenario depicting problems that a “traditional” warehouse supervisor faced when the company was acquired by a much larger “world-class” parent company. The case described many operational issues that had to be corrected in order to meet the new standards for warehouse operations, including quantitative measures that provided for the basis of analysis and problem-solving exercises by participants.

Step 3: Evaluation

The six-page “Brees Floor Covering Case” and initial workshop objectives were forwarded to the industrial distribution association officers for feedback. Comments and suggestions were incorporated into the case study document.

Step 4: Finalize the Case Study

The workshop educational materials were finalized, including the case study, instructor’s manual, supplemental readings, glossary of common terms, and supporting multimedia materials. The in-class activities and workshop schedule were developed using the following adult learning principles (Wisma, 2001):

Adults need to know why they need to learn something.

- Adults need to learn by experimentation.

- Adults approach learning as problem solving.
- Adults learn best when the topic is of immediate value.
- Adults view learning as an active process in the construction of meaning.

Findings

Writing a case study proved to be a great opportunity for us in several areas. We were able to update our working knowledge of a specific industry. The teaching of undergraduate technology students was enhanced through a sharing of responsibilities with the students. An active learning environment linked with the real world was realized through this hands-on project. An end goal for the workshop was to motivate inventory and warehouse management personnel to learn more about their industry and new techniques in their field. This case will also be valuable as a learning aid in future warehouse and inventory management classes.

We challenge educators, graduates, students, industrial representatives, and others interested in technology education to engage in educational projects of this nature. Pick an operational area or industry to research and develop a case study. The benefits and challenges are many—a journey not to be missed!

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Using Multimedia to Teach a Class on Technology and Society

Patricia Ryaby Backer

There has been considerable discussion in general educational publications about the value of instructional technology, in particular multimedia- or Web-based instruction. Much of the published work thus far has described various features of multimedia systems in an anecdotal manner rather than focusing on an evaluation of multimedia and its use in the university setting (Windschitl, 1998). In all of the discussion on multimedia, the nature of multimedia and learning using multimedia are interlinked. That is, most authors attribute positive pedagogical implications to multimedia merely because of its nature or structure (Campos, Salcedo, & Rossel, 1996; Fontana, 1993). This perspective combines two aspects of learning, what is learned and how it is learned, into one entity. This pedagogical perspective has some foundation in the literature (Bayne & Land, 2000; Fenley, 1998; Plowman, 1996; Wild & Quinn, 1998). There have been long-standing claims that students learn faster and retain more information the more they are involved in the learning process (Liu & Hsiao, 2001; Royer & Royer, 2002). Therefore, the more students interact, the more they will learn. From a theoretical perspective, Hamilton (1990) saw the curriculum as a process that should not separate what is learned from how it is learned. This duality is the fundamental identity of multimedia.

By its nature, multimedia-based learning is

more complex than traditional lecture instruction. According to Mandl (1998), there are a number of factors to consider in designing a model for complex learning. First, there must be appropriate support for complex learning, for example, the development of a multimedia structure by a teacher or peer. Second, there is the need to prepare students for a new learning environment. One major problem with innovative teaching methodologies is that there is a lack of fit between the innovative instruction and the evaluative measures (i.e., tests and examinations). The multimedia and evaluation methods should complement each other and enhance the overall learning environment.

Because of the unique nature of multimedia, problems exist with the delivery of instruction. Jonassen (1991) described three major problems that occur in multimedia: navigation (users get lost in the document), difficulty in integrating the presented information into personal knowledge structures, and cognitive overload. Also, he stated that a learner's interactions within a multimedia environment are not predictable and are less deterministic than other modes of instruction. Other researchers (Babu, Suni, & Rasmussen, 1998; Cordell, 1991) have found that a student's learning style affects achievement on multimedia-based learning. Divergers (using Kolb's learning style preference) were found to improve more on posttest

measures than those who have other learning styles. This could lead one to state that the successful use of hypermedia requires nonlinear thinking on the part of the user—this type of thinking may not be successful for all users.

It is crucial to understand the social aspects of teaching and learning with multimedia. Multimedia and Web-based courses create a different educational environment than is seen in a traditional classroom. Students bring their cultural backgrounds, university expectations, and personal computer experiences into all their learning environments, including the multimedia experience. In class, however, the instructor can adapt to students more easily than in an online environment. In an online environment, the face-to-face interaction is diminished or lost, making it more difficult for the faculty member to interpret the nonverbal cues from the students. This course is taught at San José State University (SJSU), which has an extremely diverse student body. Since learning can not be separated from the learners' historical and cultural backgrounds (O'Loughlin, 1992), this level of diversity provides additional challenges to the use of multimedia in a course.

Design and Development of the Multimedia Modules

As designer of this project, I applied for a SJSU Improvement of Instruction grant and was awarded one for the 1994 calendar year. The course chosen for this project was Technology and Civilization, a general education science-technology-society (STS) course. This course is required for industrial technology majors in the College of Engineering as well as being a popular advanced general education (GE) course for other majors at SJSU.

The GE program at SJSU (1998) is different from many in the United States. Instead of specifying a specific series of courses as part of the GE of each student, SJSU has five core GE areas (skills, science, humanities and arts, social sciences, and human understanding and development). In addition, every SJSU student must take advanced GE courses in four areas: earth and environment; self, society, and equality in the U.S.; culture, civilization, and global understanding; and written communication. Any depart-

ment may propose a course for any area of GE. The course involved in this multimedia development process was approved as an advanced GE course in the earth and environment area until spring 2000. In fall 2000, after a revision of the university GE program, the course was approved in another advanced GE area (culture, civilization, and global understanding) where it remains an approved course today.

Before any multimedia development work was done, a faculty panel revised the course syllabus. Originally, there were eight units in the course. During the discussions of the course by the faculty, there was a general consensus that there was too much course content. So, the content of the course was revised to reduce the number of units to six. After the course syllabus and content were determined, the development work began on the multimedia modules.

The first decision in the multimedia development process was the choice of authoring environment; the package chosen was Authorware for Windows. In addition, other planning decisions included discussions with the university's central computing facilities related to the use of e-mail by students and the most effective way to manage the e-mail interactions among students and with the faculty coordinator and also determining the best way to include videotaped materials: on videotapes, videodisks, or as a part of the multimedia environment using CD-ROMs.

The primary outcome of this project was self-paced modules on CD-ROMs that allowed students to explore the topics presented in this class on their own, while being able to correspond with other students and faculty by e-mail. Two units were chosen for multimedia development: Unit 1. The Nature of Science and Technology, and Unit 2. Technology and Work. The primary instruction for these modules was by a multimedia-based document that provided an organizational structure for the course. In addition, textbooks, readings, and videotapes were required by the class.

Each unit in the course was developed as a series of files using Authorware, with each unit having an introductory section (file) followed by

four to eight sections (files) in each unit. At the end of each section, students were required to complete a class activity and submit the activity to their professor by e-mail. The individual files were linked by hypertext commands so that the student would not have to run the individual files separately. The multimedia was converted to an executable version for student use. The multimedia modules included graphics, video clips, and animations that were related to the text presented in each section. The media for each section was chosen to build upon the text and was positioned on the same screen. According to researchers (Mayer, 1989; Mayer & Sims, 1994), verbal information and pictorial information are more effective if they are presented nearby rather than on different screens.

The design and development phase of this multimedia course spanned seven years, from June 1994 to May 2001. During this seven-year period, I generated five distinct versions of the multimedia modules. At each stage of the development process, the modules were evaluated by all the faculty teaching the course as well as by students in the course. The significant changes and the evaluation for each version are discussed in the sections below.

Version 1

The first version of Units 1 and 2 was used in fall 1994 and spring 1995 lecture courses as presentation modules although the entire multimedia course was not finished. The multimedia modules were structured using a modified hierarchical hypermedia. The most significant differences between Unit 1 and Unit 2 at this time relate to their navigational structures. Unit 1, designed first, was predominately linear although some of the sections contained a menu screen. As compared to Unit 1, Unit 2 was less linear in structure and the information was grouped into chunks with page numbers in each chunk.

Selected students and faculty teaching the course evaluated the modules in order to further refine these multimedia documents. In initial field tests with several students, many students reported problems with navigating (getting lost in the document) through the modules. This, according to Jonassen (1991), is one of the three

major problems that occur in multimedia. Other feedback was obtained from instructional designers at an international conference in 1996 when I presented the development and design of the first version of these multimedia modules.

Version 2

After gathering several semesters of data on Version 1 of the multimedia documents for Units 1 and 2, Version 2 of the multimedia was created in 1999. Version 2 was a minor revision that focused on the addition of enhancements including a pull-down menu to allow students to end each section in the middle and to return later to where they had left off, a change in font from serif to sanserif to increase readability, and addition of a student log-in subroutine to allow tracking of student pathways through the multimedia.

During the summer session 1999, Version 2 was field tested in one section of the class with 14 students. The students were randomly assigned to two groups: Group 1 completed the multimedia module on Unit 1 (The Nature of Science and Technology) and Group 2 completed the multimedia module on Unit 2 (Technology and Work). The summer session was organized into a one-week class with eight hours of class each day. Day 1 of the class was devoted to Unit 1 and Day 2 of the class was devoted to Unit 2. On their randomly assigned multimedia day, the students were sent to a computer laboratory where each student was assigned a computer and given a CD-ROM. Instead of attending class, they stayed in the computer laboratory and completed the multimedia. In lieu of their "regular" classwork, they completed the online class activities at the end of each section of the multimedia and submitted these to their instructor.

On the first day of class, the students were given a demographic student profile that asked their age, experience and time spent daily on a computer, and major. Also, the students were given two computer attitude questionnaires. The first was an open-ended survey with three questions designed to find out how they defined computers and their love-hate relationship with computers. This survey was developed by Morse and Daiute (1992) and was field tested by this researcher (Backer & Yabu, 1994) in a previous

study. The second survey was a revised version of Oetting's (Martin, 1998) Computer Anxiety Scale (COMPAS). These two computer surveys were given to control for any variability in the computer anxiety and/or attitudes of the two treatment groups.

In addition to the computer anxiety/attitudes surveys, all the students were given pretests for both Units 1 and 2 before either class instruction or multimedia instruction began. On the last day of class, the students were given the posttests for both units. The pretest and posttest for Unit 1 (The Nature of Science and Technology) had eight questions that were selected by faculty teaching the course as representative of the information covered in the unit. The pretest and posttest for Unit 2 (Technology and Work) had 11 questions also selected by faculty.

Students in the two treatment groups had an equivalent mean age (27 years) and similar amounts of time reported as spent on computers each day (3.09 hours/day for Group 1 versus 2.95 hours/day for Group 2). In addition, both groups showed a wide range of computer anxiety on the COMPAS; however, the mean computer anxiety score for each group was equivalent ($M = 108$ for Group 1 versus $M = 107$ for Group 2). In performance, the two treatment groups appeared to be distinctly different. Based upon the ANOVA for Unit 1, there was no difference in student performance when comparing the multimedia-based instruction with the traditional classroom instruction. The students taking the multimedia-based instruction for Unit 1, in fact, did worse on the posttest than those students in the traditional classroom. However, since the students in Group 1 had consistently worse overall performance than students in Group 2, this result is inconclusive. The results from Unit 2 were different than those of Unit 1. The results showed that both groups had significantly higher scores on the posttest than on the pretest. An ANOVA comparing the pre- and posttest scores showed an F value of 39.84 ($p < .001$). As for Unit 1, Group 2 (the students taking the multimedia for Unit 2) performed better on the posttest than did Group 1 although the difference was much less ($M = 7.7$ for Group 1; $M = 8.4$ for Group 2).

Overall, the multimedia for Unit 2 led to higher student achievement than either the "regular" classroom instruction or the multimedia for Unit 1. The qualitative evaluation of the multimedia modules was examined to see if there were any commonalities that indicated why the Unit 2 multimedia was more successful. Ten of the 14 students completed a qualitative evaluation of the multimedia modules. All 10 students liked the multimedia modules for the class. As one student stated, "I liked the video interactions, they allowed me to comprehend the material better." Another student noted, "I found the multimedia portion of this class to be very impressive. I really enjoyed the freedom and convenience of the CD ROM. The content allowed me to gain specific knowledge on specific subjects that I would not have otherwise known about." Overall, the students taking the Unit 1 multimedia found they had a harder time navigating through the material. Since Version 2 of the Unit 1 multimedia presented the material in a linear fashion, the students did not know where they were in the course of the lesson. Also, they noted that it was difficult for them to review previous material. The students who took the Unit 2 multimedia complained about the amount of material in each section.

Version 3

Overall, there appeared to be several issues related to the multimedia modules. Both the Unit 1 and Unit 2 feedback from Version 2 related to two multimedia design issues: navigation and narrative structure. To increase student control of the learning environment, controls were added to all video clips in both Unit 1 and Unit 2 that allowed students to pause, play, and stop videos. Also, each section in Unit 1 and Unit 2 included a class activity at the end so that the students could achieve closure on each topic.

It was evident from the qualitative and student outcomes that the navigational structure of Unit 2 was better than that of Unit 1. However, a problem still existed with the narrative structure. Because the information was not presented in a clear, organized manner, the students' learning was adversely affected. As Laurillard (1998) pointed out in her research, "learners working on interactive media with no clear narrative structure display learning behaviour [sic] that is gen-

erally unfocused and inconclusive” (p. 231). The chunking of information is interlinked with the narrative structure of multimedia. Because the teacher-storyteller is remote from the student-listener, the design of the multimedia and the chunking of its content need to be more robust.

At this time, it was decided to complete a structural change of Unit 2 to address both the issues of chunking and narrative structure before making any substantive revisions to Unit 1. The three sections of Unit 2 were reorganized completely and divided into eight parts: The Industrial Revolution, Industrialization of Society in the 19th Century, Workplace of 1900, Scientific Management, The Development of the Assembly Line, Consumerism in the West, Nature of Work Today, and How Does Technology Affect the Workplace? The content in each section was revised so that the students could reread a section without restarting from the beginning. This reorganization provided a better narrative structure and, at the same time, increased learner control. As Steinberg (1989) found, increasing learner control can make the learning experience more motivating as well as increase student learning.

Version 3 was used in the winter 2001 class as a replacement for the in-class instruction. On the first day of class, the students were given the multimedia CD-ROMs for both units and were asked to complete them at home or in one of the department’s computer labs. Each week-day during the winter term, students would e-mail the appropriate class activities to their instructor. A review of the class activities submitted by the students indicated that they learned the subject matter for both units. After the multimedia modules were finished, the students returned to the classroom. Since all the students in the class used the multimedia modules, their performance was compared with a previous winter 1999 class (taught entirely in a “traditional” mode). The winter 2001 class ($M = 84$), on average, achieved higher grades on the final exam than did the winter 1999 class ($M = 78$), but the results were not significant. Results from the qualitative evaluation showed no more complaints about navigation or the amount of content in each section for Unit 2 and indicated that the students viewed the experience in a pos-

itive light. Overall, the students preferred the navigational design of Unit 2 to that of Unit 1. Overwhelmingly, the comments were positive about the multimedia modules. There was one significant student suggestion for this version of the multimedia. The students wanted the ability to print out the text easily. (Since this multimedia was constructed using Authorware, students could not “cut and paste” the text on the screen as they were accustomed to doing on the Web.)

Versions 4 and 5

Version 4 was the last major revision of these multimedia modules. The work for this revision centered on Unit 1. Based upon the feedback from Version 3, Unit 1 was completely redesigned to follow the “look and feel” and structure of Unit 2. The new Unit 1 was less linear and the information was grouped into chunks with page numbers in each chunk. The existing six parts for Unit 1 were re-divided into seven sections: the old section *What Is Science and Technology?* was divided into two sections: *What Is Science?* and *What Is Technology?* Also, all the video clips for both units were recaptured at higher resolution and converted to QuickTime format in Unit 1. I added a new pull-down menu with an option to view the text in each section as a text file. (This was done to address students’ complaint that they could not easily print the text.) Also, the class activities were revised and a few links to Web sites were added. All the movies in both units were changed to allow student use of a standard Quicktime control bar. The multimedia was ported to the Macintosh platform so that students could use either a Windows or MAC computer to view the material.

Beginning in the fall 2000 semester, all instructors in all sections began to use the multimedia modules in their classes. Most of the instructors used the multimedia as self-paced learning while other instructors used the modules as a supplement to in-class discussion sessions. Since all of the instructors used the modules, there was a greater amount of feedback from both the instructors and the students. This dissemination created additional challenges for the instructor and author (who also served as the course coordinator). As Zirkle and Ourand (1999) found, teaching a course through multiple deliv-

VERSION	MAJOR CHANGES
Version 1 November 1994	Six parts: (a) What Is Science and Technology? (b) What Is Scientific and Technological Literacy? (c) The Scientific Method, (d) Attitudes Toward Technology, (e) Technology Dependence and Technology Traps, and (f) Impact of Technology on Society. Each part predominately linear, some contain a menu screen. All sections loop back to the menu screen. Limited student control over videos. Files named numerically. Each part contains a cumulating class activity.
Version 2 August 1999	Minor revision. Same basic structure as Version 1. Added navigation pull-down menus. Changed fonts to sanserif. Added student login to track information. Files given more descriptive names.
Version 3 November 2000	Redesigned color scheme and fonts. Added controls to all videos; controls allow students to pause, play, and stop videos. Redesigned class activities.
Version 4 June 2000	Seven parts: What is Science and Technology? was divided into two sections: What Is Science? and What Is Technology? Completely redesigned the structure to follow the “look” and structure of Unit 2. Less linear, information is grouped into larger chunks with page numbers in each chunk. Added a new pull-down menu with option to view the text in each section as a text file. Revised the class activities and added a few links to Web sites. Revised colors and fonts so that entire unit has a consistent color scheme. Recaptured all video clips at higher resolution and converted to QuickTime format. Changed all movie clips from movie icon to QuickTime media with control bar.
Version 5 May 2001	Minor revision. Same basic structure as Version 4. Revised content of several sections.

ery formats, in this case multimedia as well as lecture, requires new expertise on the part of faculty. During the fall 2000 semester, there were several technical issues that needed to be resolved with various faculty. As faculty experience with the multimedia increased each semester, there were fewer problems and less faculty anxiety about using these modules as an integral part of their class.

The last revision of the multimedia modules, Version 5, was minor and focused on updating and revising the content in several sections. For four semesters, all the faculty currently teaching this course have used the multimedia in their classes. Now, these multimedia modules are required for all sections of this course. There are plans to update the content in each multimedia every two years.

A Worthwhile Effort

The development process of multimedia modules for a GE course at SJSU was very long and complex. In fact, the development cycle of these multimedia modules spanned seven years and five separate revisions. When first proposed in 1994, the process was envisioned as a one-year project. However, there were many twists and turns along the way. Because of the nature of multimedia, there is the expectation that changes in multimedia material will happen frequently. These changes, whether small or large, can be very time consuming. For example, the relatively small change to add a pull-down menu to allow students to print the text (made in Version 4) took six weeks because of the number and size of the multimedia files.

VERSION	MAJOR CHANGES
Version 1 November 1994	Three parts: (a) History of Technology and Work, (b) Nature of Work in the 20th Century, and (c) How Does Technology Affect the Workplace? Each part contains a menu screen. All sections loop back to the menu screen. Less linear, information is grouped into larger chunks with page numbers in each chunk. Navigation pull-down menus. Added student log-in to track information. Files named numerically. Each part contains a cumulating class activity.
Version 2 August 1999	Minor revision. Divided into four parts. The History of Technology and Work section was split into two files: The Industrial Revolution and Industrialization of Society. Same overall content structure as Version 1. Added student log-in to track information. Files given more descriptive names.
Version 3 November 2000	Reorganized completely and divided into eight parts: The Industrial Revolution, Industrialization of Society in the 19th Century, Workplace of 1900, Scientific Management, The Development of the Assembly Line, Consumerism in the West, Nature of Work Today, and How Does Technology Affect the Workplace? Added Previous Section and Next Section buttons to all content chunks (allows students to reread a section without restarting from the beginning). Added more content to the sections. Added controls to all videos; controls allow students to pause, play, and stop videos. Changed font. Redesigned class activities. Added additional video clips. Recaptured all video clips at higher resolution and converted to QuickTime format.
Version 4 June 2000	Minor revision. Added a new pull-down menu with option to view the text in each section as a text file. Revised the class activities and added a few links to Web sites. Revised colors and fonts so that entire unit has a consistent color scheme. Changed all movie clips from movie icon to QuickTime media with control bar.
Version 5 May 2001	Minor revision. Revised content in two sections: Nature of Work Today and How Does Technology Affect the Workplace?

The original development of the first version of the multimedia modules took longer than had been estimated. Also, there was a significant time gap between the publication of Versions 1 and 2. This delay can be attributed to several factors—fatigue with multimedia being the primary one. This factor is infrequently mentioned in the literature. It takes an extraordinary amount of time to develop fully functional multimedia modules. Another cause for the time delay between versions was a university restructuring of the GE program—this multimedia project was put on hold until the class was recertified for GE. A consistent time constraint existed throughout the life of this project. I also work at a teaching institution where the course load is typically four different classes each semester (12 units). This heavy teaching load reduced the amount of time available to work on

the multimedia modules during the academic year.

Technical problems constantly occur in multimedia development. And, it seems that often the solution to one technical problem leads to a new one. The story of the video clips in this multimedia project highlight this sort of technical problem. Originally, most of the video clips were captured at 120 X 160 screen resolution in 1994–1995 at 10–15 fps. Then, they were compressed using Digital Video Producer or Adobe Premiere to Microsoft AVI format using Cinepak, Intel Indeo, or Microsoft Video 1 compression. The quality of the video for the time (1994–1995) was fine; but in 1999 I decided that the videos needed to be recaptured at a higher resolution and frame rate. Also, since 1999 there has been an increase in the number of students using the MAC platform; therefore, all the new

recaptured videos had to be converted into Quicktime format so that the video clips could be viewed on both platforms. At the same time, the version of Authorware changed. Version 1 of this multimedia was authored using Authorware 2 while Version 5 was authored using Authorware 5. A new technical problem occurred with Version 4 of the multimedia. On certain Windows platforms (Windows NT, for example), the Quicktime videos would not run. Eventually, this technical problem was resolved by changing the programming in Authorware from a movie icon to a media type. Because of the financial constraints at SJSU, I was forced to allocate time to many programming issues. This time reduced the amount of time available for academic research and development projects.

Since the first version of the multimedia was published, there has been more research that has indicated the importance of good interface design in the context of learning (Maddux, Johnson, & Willis, 1997; Shneiderman, 1997). Brown (2000) called visual and design principles the forgotten partner in multimedia and Web development. As I learned the hard way through the student feedback to Versions 1 and 2, bad design and organization increases confusion in learners and causes them to “get lost.”

Most developers of multimedia assume that media-rich technologies help students form a deeper understanding of the material (Bayne & Land, 2000). The qualitative and quantitative evaluations I have conducted over the past few years show that this is almost always the case (Backer, 1995, 2000). The multimedia is “self-paced” and “empowering,” to quote two of the students surveyed, but it also behaves in unexpected ways. Students bring their existing worldviews and perspectives to their learning experience, and a multimedia learning environment does not give them the cues they are accustomed to from their professors. This is one reason that this course is a hybrid course rather than a multimedia-only course. A hybrid course balances multimedia instructions with discussion sessions with students. This structure allows the students to interact with each other and the instructor about the content and solves many problems inherent in self-paced instruction including high dropout rate, student lack of

focus, and difficulty in integrating the presented information into personal knowledge structures.

Most of the existing research shows that there is no significant difference in student achievement using multimedia as compared to “traditional instruction” (see Russell, 2000, for a review). Therefore, the debate should change to focus on increased access to education. Self-paced multimedia and Web-based courses give more access to more learners. The use of these CD-based modules has allowed students to have more flexibility in completing their GE requirements. In addition, it has allowed the department to serve a larger number of students with less faculty leading to higher FTEs and SFR. This is only one of two advanced GE courses in the College of Engineering at SJSU; therefore, this method of providing instruction provides more options and more flexibility to students in the completion of their GE requirements.

Beyond the effect on the curriculum at SJSU, this mode of delivery provides an opportunity for all STS courses. In this course, these multimedia modules seek to explain the nature and history of technology by using technology. The direct purpose is to provide in-depth course content for all instructors of this course. Indirectly, these modules give students the experience of using advanced technologies to learn about the nature of technology. Although the dichotomy is not directly stated in the multimedia materials, most students comment on the indirect messages about technology and their additional experiences, in this course, with technology as a learning medium.

As more universities consider adding STS courses to their curriculum, the delivery of these courses through multimedia can add depth to the story they are telling about the relation of technology to society. By using the Web and multimedia, student experiences can be enhanced and students can get a richer, more complex view of technology and its effects on our world.

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An Evaluation of Internet-Based CAD Collaboration Tools

Shana Shiang-Fong Smith

During product design, over 80% of engineering changes are needed because designed parts cannot be manufactured or assembled (Stevens, 2001). Most of the design errors are due to lack of communication between the design team and manufacturing experts. To reduce communication problems and, thereby, increase product quality and reduce production costs, industry

has turned to concurrent and collaborative engineering methods (Prasad, 1996). However, in today's global market, designers and manufacturers are often geographically separated. Thus, designers, manufacturers, and suppliers need powerful communication tools so they can exchange design information effectively (Jones, Schwemin, Dorneich, & Dunmire, 2000).

The objectives of collaborative design include optimizing the mechanical function of a product, minimizing production or assembly costs, and ensuring that the product can be easily and economically operated and maintained. Effective collaboration tools can help resolve product design conflicts early in the design stage. As a result, product development, lead-time, and manufacturing cost can be greatly reduced. Thus, companies that use collaborative design tools realize many benefits. For example, by using a collaborative design tool to create its LBP-1210 laser printer, Canon was able to reduce design iterations, total cost, and lead-time (www.cocreate.com). Hewlett-Packard found that using a collaborative design tool helped immediately reduce overseas travel costs. Overall, using a collaborative design tool helped HP achieve a 135% return on investment (ROI) after one month and 240% after three months (www.cocreate.com).

Modern design teams often use CAD/CAM (computer aided design and computer aided manufacturing) tools to help facilitate their design process, from conceptual design stage to final production. Different companies or design partners may use different CAD/CAM tools. Since most existing CAD/CAM applications were designed to work in an isolated environment, inconsistent file formats often cause problems during information exchange.

Due to the now widespread use of the Internet, most companies now require CAD tools that support distributed collaborative design on the Internet (Lavara, Brglez, Reese, Konduri, & Chandrakasan, 2000). Such CAD tools should enable designers to share product models, as well as related data, from geographically distant locations (Shyamsundar & Gadh, 2001). However, integrated collaborative design capability over the Internet has not fully matured. For example, Potter (1997a) found that security and authentication are still major concerns when transferring CAD files over the Internet. Designers or companies need to protect intellectual property (Fornaro & Sanna, 2000).

This article determines the Internet-based collaborative design capabilities available in modern CAD tools, outlines the major problems

that still need to be addressed (e.g., version control, data translation and repair, and security and legitimacy issues), and recommends directions for future research.

Collaborative Design

According to Wang, Shen, Xie, Neelamkavil, & Pardasani (2001), if a product is designed through the collective and joint efforts of many designers, the design process used can be called collaborative design. The collaborative design process might include all design activities from concept creation through product definition, detailed design, manufacturing, assembly, maintenance, and even product retirement. Furthermore, some companies may enhance the collaborative design process by involving their customers, suppliers, and partners, over the Internet, throughout the product development and delivery process (Waltham, 2000).

Due to the often distributed nature of modern, Internet-based collaborative design processes, many different CAD tools may be used by a collaborative design team. When design teams use different CAD tools, problems often arise because different CAD tools still use different native file formats. For example, Autodesk Inventor generates part files in .ipt file format, and Pro/E generates part files in .prt file format. If design team members must share data stored in both file formats, a problem in model consistency might exist. Data communication problems due to using the Internet as a communication channel may also exist.

Therefore, collaborative CAD tools need a common, secure communication framework and protocol so that CAD files can be transferred safely and accurately. To meet the need, many CAD tools have recently added at least some of the following collaborative design capabilities: (a) real-time communication, (b) support for various CAD formats, (c) tools for publishing 2D/3D CAD designs on the Web, and (d) tools for manipulating CAD models outside the original CAD program.

Real-Time Communication

The Internet is probably the most convenient medium available for sharing CAD files in real time. CAD program vendors have begun to

use the existing power of the Internet and many existing Internet-based communication tools to improve the collaborative capabilities of their CAD programs. For example, to help designers share design data and models over the Internet, CAD vendors have begun to incorporate Internet-based conferencing and real-time 3-D model viewing tools directly into their products (Shyamsundar & Gadh, 2001). Autodesk integrates Windows NetMeeting into the latest version of Inventor. NetMeeting includes chat, whiteboard, program sharing, file transfer, remote desktop sharing, security, and video and audio conferencing. Thus, Autodesk Inventor users have online real-time communication capability available within the Inventor design environment. Table 1 provides a summary of collaborative functions available in Windows NetMeeting (Microsoft, 2001).

Toc20151059Windows NetMeeting remote desktop sharing allows a remote user to run a CAD program, which has been installed on a local computer, over the Internet. With remote desktop sharing, the remote user can use the local CAD program, running on the local machine, without having to install a copy of the CAD program at his or her remote site. As a result, the remote user can participate in a collaborative design session while at the same time reducing CAD program investment costs.

Support for Various CAD Formats

To share CAD files, collaborative design teams often must transfer CAD data from one CAD tool to another over the Internet. To deal with the issue, collaborative designers can store design files in a neutral file format. For example, if Company A in the U.S. uses AutoDesk Inventor while Company B in Japan uses Pro/E,

with current versions of Inventor and Pro/E, Company B could not read an Inventor .ipt file sent via the Internet by Company A. However, for successful collaborative design, Company A could save its CAD files in STEP (or another neutral file format) and then transfer the resulting STEP files to Company B via the Internet. Most modern CAD tools currently support several design file formats to improve their compatibility with other CAD tools. SolidWorks, for example, supports IGES, DWG, VRML, STL, VDA, SAT, DXF, and STEP file formats.

Tools for Publishing and Viewing 2D/3D CAD Designs on the Web

Distributed design teams need tools that address critical communication issues that are not addressed in stand-alone CAD tools. Often, for distributed design teams, customers, suppliers, vendors, and development partners who do not have CAD tools or CAD-tool expertise need to view and evaluate developing designs. To solve the problem, CAD vendors have begun to develop tools for publishing designs on the Web. For example, Parametric Technology Corporation () now offers a stand-alone tool called ProductView, which allows customers and other distributed design team members to preview designs on the Web, thus reducing product design and modification time and cost.

Tools for Manipulating CAD Models Outside the Original CAD System

Some CAD vendors offer stand-alone tools that provide more than just viewing capability. With tools for manipulating CAD models outside the original CAD environment, collaborative design team members without CAD tools or CAD-tool expertise can quickly and efficiently review design models. Manipulation tools allow

Table 1. Summary of Collaborative Functions in Windows NetMeeting.

FUNCTION	KEY FEATURES
Chat	Conducting multi-user real-time conversations using text
Whiteboard	Communicating in real time using graphics
Program sharing	Sharing programs during a conference
Remote desktop sharing	Operating a computer from a remote location
File transfer	Sending files in background mode during a NetMeeting conference
Security	Using security measures to protect privacy
Video and audio conferencing	Communicating on the Internet using video and audio

Table 2. Viewers Provided by CAD Companies.

Company Product	File Format Supported	Tools for Publishing CAD Designs on Web	Add Note/ Mark Up	URL
Solid Concepts SolidView	<ul style="list-style-type: none"> Object (.obj) SolidFile Exchange (.sfx) SolidWorks (.sldprt, sldasm) Stereolithography (.stl) VRML (.wrl) 	N/A	✓	http://www.solidview.com
Parametric Tech. Corp. ProductView	<ul style="list-style-type: none"> CADD DWG IDEAS Pro/E SW UG 	✓	✓	http://www.ptc.com
EDS Solid Edge Web Publisher	<ul style="list-style-type: none"> 3D IGES/2D IGES VRML DXF DWG 	✓	Object	http://www.solid-edge.com/
SDRC Metaphase 3.2	<ul style="list-style-type: none"> BMP CGM DWG DXF GIF HPGL 	✓	Object	http://www.sdrc.com/metaphase/index.shtml
SolidWorks eDrawings Professional	<ul style="list-style-type: none"> SolidWorks 2001 SP10 or higher AutoCAD 2000, AutoCAD R14.x AutoCAD Mechanical R14.5 SolidWorks design data AutoCAD design data 	✓	✓	http://solidworks.com
SolidWorks SolidWorks Viewer	<ul style="list-style-type: none"> IGES DWG VRML Parasolid® STL, ASCII, or binary format VDAFS (VDA) SAT (ACIS) DXF STEP 	N/A	N/A	http://solidworks.com
Autodesk Volo View	<ul style="list-style-type: none"> DWG (AutoCAD-base) DXF DWF Raster drawings Inventor (.ipt .iam .idw) 	N/A	✓	http://usa.autodesk.com

users to translate, rotate, pan, zoom, and mark-up CAD models.

As an example, Autodesk offers Volo View Express, a free tool for viewing and manipulating Autodesk-format CAD files without Autodesk CAD tools installed. Volo View

Express allows users to open, view, make light-weight markups, and print CAD designs. Volo View Express supports Autodesk DWG, DXF, and DWF (ePlot and eView) file formats. With an additional downloadable Autodesk Inventor plug-in, VoloView allows users to view and print Autodesk Inventor part, assembly, and drawing

files without Inventor installed. Table 2 presents a list of tools offered by major CAD vendors for viewing and manipulating CAD files and the corresponding supported file formats.

Some third-party companies also provide CAD tools for viewing and modifying different types of CAD files online. For example, OneSpace Designer (from Cocrete Corp., www.cocreate.com) and IX SPeeD Suite (from ImpactXfot, www.impactxoft.com) allow users to load, view, inspect, and modify different types of CAD files during concurrent and collaborative design projects.

Issues in Collaborative Design

Update Issues

While working on a project, collaborative designers frequently make changes to parts that are being accessed at the same time by others working on the same project. One of the biggest problems with many Internet-based collaboration tools is that they do not have built-in multi-user version control capability. As a result, users can mistakenly use an older version of a file, rather than the latest version. Drawings may be sent out and considered final when they actually are not. Therefore, efficient collaborative design tools must support inconsistency prevention and detection (Despres, Piloty, & Schellin, 1993).

Many existing single-user CAD tools allow the user to set model version numbers to help track any design changes made during the product development process. Each time a model's content is modified and saved in a working file, the tool assigns a new version number to the working file. A new version of the model is created each time the file is saved. Usually, the CAD tool, after the number of saved versions reaches a maximum limit (for example, 10 in AutoDesk Inventor), discards the oldest version of the model whenever a new version is saved. The user can then open, view, and modify any saved version of the model.

To allow multiple users to access the same files, AutoDesk added a multi-user option to Inventor. Users must select the multi-user option before starting work on a collaborative project. With the multi-user option selected, all members of a group can access the same project files.

AutoDesk Inventor also enables safeguards when several users are editing the same files.

After a user activates the file reservation system and warning functions inside AutoDesk Inventor, Inventor automatically reserves any new files the user creates for that user. If another person attempts to edit a reserved file, a warning message alerts the person for whom the file is reserved.

Data Translation and Repair Issues

In a collaborative design environment, team members might use different design software when working on a model. A major problem with using various heterogeneous CAD programs is lack of interoperability between the systems (NIST). Data translation issues cause many concerns (Potter, 1997b). For example, a designer could receive three parts from three different design team members in three different file formats, e.g., an Inventor (.ipt), a Pro/E (.prt), and a STEP (.stp) file. To combine the three parts into a single design, the designer would need to translate all the files into a format supported by his or her CAD tool and then import the parts into his or her CAD tool.

The design team could eliminate both the problem due to mismatched file formats and the time required for data translation by saving and transferring CAD part designs in a neutral file format (e.g., STEP or IGES). However, saving and transferring CAD files in neutral file format does not remove problems with internal data consistency.

Since different CAD tools often use different internal accuracy levels, a target system may not be able to recognize an imported model as a solid body after data conversion. Errors such as cracks, degeneracy, duplication, holes, and overlaps usually occur in the models when users import them from other CAD tools (Barequet & Kumar, 1997). Upgrading a low-resolution solid model into a high-resolution solid model can be a difficult problem. Often, users need an expensive repair and healing tool to make the model usable (Farrell, 1999). In addition, state-of-the-art healing tools often cannot successfully repair imported CAD models.

A 1999 study by RTI International (<http://www.rti.org>) estimated that imperfect interoperability imposes costs of at least \$1 billion per year on the U.S. automotive supply chain alone; other industries face similar difficulties.

Internet Security and Legitimacy Issues

With the explosive growth in Internet use, network security has become an inevitable concern for a growing number of organizations (Yu & Le, 2000). Since CAD files often serve as legal documents, cautious CAD users may not be willing to use any tools that create a risk of exposing their designs to outsiders (Hauck & Knol, 1998). Users often express concerns about having their files stolen during transmission (Farrell, 2000), and many people are not totally comfortable when sending information across the Internet. Users often believe that if a file is sent over the Internet, someone might steal or modify the file. Indeed, some surveys already indicate that many companies are not willing to use the Internet to transfer their CAD data (Potter, 1997a). Thus, in the future, collaborative CAD tools must offer more capabilities for securing files and encrypting models.

Speed Issues

Speed is another issue facing Internet-based CAD researchers and developers. Today's fast Internet connections allow almost immediate response for low-density data. However, CAD data generally contains a large amount of information in every file. As a result, current collaborative CAD tool users need to, but currently cannot, see design animations in real time. Without even higher-speed Internet connections, collaborative CAD users might find their modeling experiences very frustrating. Therefore, in order to manipulate CAD models in real time, more advanced communication hardware and software are required.

Conclusion

Growing Internet use has led to Internet-based collaboration functions in major CAD packages. With currently available capabilities, users can exchange and share CAD files in real

time using Internet-based conferencing utilities. Furthermore, some major CAD vendors now offer tools for publishing 2D/3D CAD designs on the Web and for viewing and manipulating CAD models outside the original CAD program. With CAD model Web publishing, viewing, and manipulating tools, collaborative design team members can communicate effectively, even from different geographical locations, without purchasing or installing separate copies of the CAD tool(s) used. Most major CAD tools now offer support for saving and importing CAD files in several different file formats (in particular, neutral file formats such as STEP and IGES), which is a critical feature for collaborative design. With neutral file format capability, collaborative CAD file exchange over the Internet is becoming easier.

Remaining problems facing collaborative CAD tool researchers and developers include technical difficulties related to data translation and file security. Data translation often leaves cracks, degeneracy, duplications, holes, and overlaps in models. Security issues on the Internet leave many companies concerned that their designs might be lost, stolen, or modified when transferred over the Internet.

Improved Internet-based collaborative CAD tools can enhance communication in the CAD/CAM industry. As a result, collaborative CAD tools can also reduce product development and manufacturing costs. As Internet use becomes more widespread, Internet and computer networking capabilities will continue to improve. However, capabilities in collaborative tools for CAD/CAM design need to improve as well. A review of current collaborative CAD capabilities shows that although some capabilities exist, further research and development is needed, particularly in the areas of data repair, data integrity, and data security.

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A Model to Integrate Online Teaching and Learning Tools Into the Classroom

Klaus Schmidt

With the evolution of the World Wide Web, online teaching and learning has gained a tremendous amount of popularity. New Web teaching and learning tools are created at a fast pace to help better address the multitude of teaching and learning styles. Liu and Thompson (1999) found that faculty members are more likely to use a wider variety of educational technologies when exposed to online teaching and learning tools and thus teach to a broader array of learning styles. The increasing diversity of learning strategies is a growing challenge for teachers. One way to address this challenge is to incorporate online learning tools into the traditional classroom. Such a combination may benefit both students and teachers if those tools provide quality teaching and learning opportunities and outcomes. However, little research exists on how learning environments can be created that successfully combine online teaching and learning with traditional classroom environments to enhance student learning.

This article introduces a model that addresses how an effective combination of online and traditional classroom teaching can be obtained. The article shows how learning outcomes and preferences as well as the awareness of student characteristics and student feedback such as the perception of classroom environment can be used to enhance the quality of a combined learning environment.

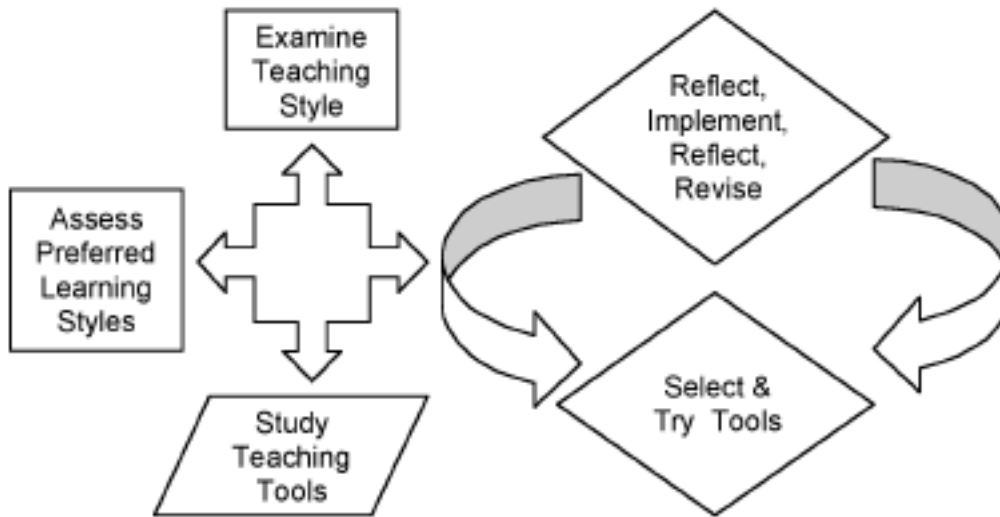
Students' perceptions of the classroom environment are indicators of successful learning. Cheung (1998) stated that student feedback is essential for improving the academic quality of online learning. Sherry, Fulford, and Zhang (1998) discussed the positive relationships between students' satisfaction with instruction and their subsequent success in a course. Fitzelle and Trochim (1996) found that enjoyment and control of pace were significant factors in student success with online instruction. It follows that assessing students' perceptions of their preferred instructional environment is an integral

role in developing instruction that motivates students to achieve desired learning outcomes.

When considering the replacement of one teaching method or tool with another, it should be assured that the quality of the learning experience is not diminished. It is important to not simply accommodate students' preferred learning styles, but also to expand on students' learning strategies by exposing them to other viable and interesting ways of learning. The combination of online learning with traditional classroom instruction could diversify teaching and learning alike, and as a bonus enhance technological literacy of both the faculty and students.

Literature identifies various models of combining online learning with traditional classroom learning and assessing the quality of such combinations (Eberling, 2000; Grasha & Yangarber-Hicks, 2000; Simon, 2000; Spoon & Schell, 1998). In general, students participating in entire classes online have demonstrated no significant differences in learning when compared to students taking classes in traditional classroom settings (Benbunan-Fich & Hiltz, 1999; Johnson, Aragon, Shaik, & Palma-Rivas, 2001; LaRose, Gregg, & Eastin, 1998; Swan & Jackman, 2000). Wheeler and Jarboe (2001) added that a combination of online and traditional classroom instruction has become the most popular way to use Internet teaching and learning tools. LaRose et al. (1998) discussed the potential of online learning to enhance individual student learning. Furthermore, Ester (1994-95), Goldberg (1997), and Wheeler and Jarboe (2001) found that students with access to both traditional lectures and an online environment fared better academically than students instructed either entirely in the traditional classroom or entirely via the Internet. Sanders and Mirrison-Shetlar (2001) found that including Web-based components in an otherwise traditional college level biology course increased student learning and enhanced problem-solving skills.

Figure 1. Model for incorporating online teaching tools.



The model presented in Figure 1 suggests five considerations that may be useful when creating a quality mix of online and traditional classroom teaching and learning. The steps Examine Teaching Style, Assess Preferred Learning Styles, and Study Teaching Tools can occur simultaneously or in any order. It is recommended that the instructor fully understands and completes the first three steps prior to moving on to Select and Try Tools and then Reflect, Implement, Reflect, and Revise. The entire process is ongoing and iterative. Each step is explained in more detail on the following pages.

Step 1: Examine Your Teaching Style

Assessing the preferred personal teaching style is one of the first steps a teacher should take prior to selecting and implementing online teaching and learning tools. Understanding one's personal teaching style can help to determine which traditional course components can be best enhanced with online teaching and learning technology and which tools will most comfortably match the teacher's personal teaching style. Preferred teaching style may be identified through careful personal reflection or through use of any of a number of available instruction/teaching styles inventories. Two common instruments designed to assess teaching styles are the Canfield Instructional Styles Inventory (ISI) and Grasha's 5 Teaching Styles Inventory. The ISI categorizes teaching styles along two basic dyads: social or independent, and conceptual or applied. For example, if the

identified teaching style is social, a teacher wishing to incorporate online instructional components might consider which available online tools could effectively replace or supplement traditional social instructional techniques such as group discussion and team activities. Online chat rooms or discussion tools designed to create a social learning environment and a sense of community between teacher and students might be helpful. Conversely, if after consideration it is determined that the existing online tools do not meet these particular needs, the teacher might refrain from using online chat rooms or discussion tools to supplement classroom teaching in this instance.

Grasha's 5 Teaching Styles Inventory describes teaching styles within five major categories: facilitator, formal authority, expert, personal model, and delegator. If a teaching style is predominantly the role of a facilitator, the teacher should identify tools that help to support the facilitator role¹. On the other hand, if the teaching style is identified as expert, the teacher might include video or audio enhanced presentations and lectures.

With respect to identifying the teaching style, this model does not give preference to any particular teaching style or teaching styles assessment tool. The teacher is free to choose whichever approach he or she is comfortable with. It might even be helpful to choose multiple instruments or approaches as each addresses different

elements of teaching styles. Nevertheless, being aware of teaching styles alone does not guarantee that student learning takes place. In order to facilitate student learning, a teacher also needs to consider and be aware of his or her students' preferred learning styles.

Step 2: Assess Your Students' Preferred Learning Styles

Understanding how students learn is imperative. This is especially true when considering the incorporation of a greater variety of teaching tools, as is the case when combining online and traditional classroom teaching. Several studies (Ayersman & Reed, 1995-96; Ester, 1994-95; Ross, Drysdale, & Schultz, 2001) have found relationships between learning styles and student perceptions of and/or learning successes with online instructional components. In a study designed to decrease the levels of students' computer anxiety, the highest level of computer anxiety was demonstrated by students identified as divergers and the lowest levels were demonstrated by students identified as convergers using the Kolb Learning Styles Indicator (Ayersman & Reed, 1995-96).

Literature discusses a wide array of instruments to assess learning styles (Crowe, 2000; Dunn & Griggs, 2000; Miller, 2001). Four commonly used instruments are the Myers-Briggs Type Indicator (MBTI), the Kolb Learning Style Indicator, the Canfield Learning Styles Instrument (LSI), and the Dunn, Dunn, and Price Productivity Environmental Preference Survey (PEP). While the MBTI focuses on the four dimensions of extroversion versus introversion, sensing versus intuition, thinking versus feeling, and judging versus perceptive, the Kolb Learning Style Indicator collects student information on four scales including preference for concrete experiencing, abstract conceptualization, reflective observation, and active experimentation. The Canfield LSI places learning styles into categories such as social, independent, applied, and conceptual. The PEP profiles student learning preferences in such learning related factors as noise and light levels, temperature, motivation, persistence, structure, authority, senses, time of day, etc. However, it might not always be necessary to formally assess students' learning styles.

Information about students' preferred learning styles may be collected informally through discussions with students or observations of students in the classroom.

Once a teacher has identified his or her teaching style and is able to identify students' learning styles, an appropriate mix of online and traditional teaching and learning tools may be identified. For example, if the LSI is used and students identify themselves as social learners, it will be beneficial to incorporate online and traditional teaching and learning tools such as online chat rooms or discussion tools. If the social learning style cannot be adequately met using only online tools for a particular course, the instructor might decide to emphasize the social learning style more heavily using traditional classroom tools or a combination of traditional and online tools. If a teacher's teaching style is learner centered but the students prefer the teacher centered environment, students may obtain lower learning outcomes due to a mismatch of teaching and learning styles. In such a scenario, the teacher could identify and apply or supplement learner-centered instruction with tools that enhance a teacher-centered learning style. This approach would not only widen students' learning strategies but also a teacher's portfolio of teaching techniques. Matching the teaching style with the learning style of students may not solve all issues related to learning in the college environment, but it could help to identify Internet technologies for a better integration of traditional and online teaching and learning tools and thus address a wider variety of learning styles.

Step 3: Study Online and Traditional Teaching and Learning Tools

A good command of both online and traditional teaching and learning tools is important for the development of a successful combination of those tools. The following section focuses on online teaching and learning tools and on how these tools can be incorporated into the classroom.

A broad array of online teaching and learning tools are available. Almost all aspects of classroom teaching can be enhanced or replaced with online technology in some contexts. To obtain a broader overview of enhanc-

ing the classroom with Web technology, the classroom environment can be categorized into four components: administration, assessment, content delivery, and community (Schmidt, 2002b). Various online tools exist to help in these components. Appropriate selection of online tools will depend not only on the instructional content but also on the quality of the available tools and the level of technical ability of teacher and students. For example, if both teacher and students have mastered a specific content delivery tool, it can be beneficial to deliver content online rather than in the classroom. Similarly, if the teacher has found ways to meaningfully incorporate synchronous communication tools (such as chat), students might also benefit from the added community component. The following discussion of each component will demonstrate how Web tools could be incorporated to meet certain aspects of a course to enhance student learning.

The administrative component is the foundation for the organization of a course and allows a teacher to spend more class time interacting creatively with students rather than on mundane activities. For example, activities such as turning in or returning graded assignments during class time can be replaced with Internet technology. The time “gained” during class can then be used for other higher order thinking and learning activities. The assessment component addresses student performance. Using online assessment tools such as online quizzes to provide instant feedback and repeated testing opportunities for practicing purposes may help students learn the subject matter more thoroughly. This method also leads to more class time for student-student and student-teacher interaction (Schmidt, 2002b). Sanders and Morrison-Shetlar (2001) found that students were comfortable tracking quizzes and tests online and liked having online access to their individual grades to assess how well they were doing in the coursework.

The content delivery component focuses on the communication of course content and learning activities. Research shows that a significant amount of learning can take place outside the traditional classroom if students have access to and are motivated to study the material at their

own pace. Ryan, Hodson Carlton, and Ali (1998) found that students enjoy using the Internet for the structured presentation of course material and prefer traditional class time to be used for informal interaction and the development of advanced thinking skills.

The community component addresses development of a community of learners, the sense of community among students and between teachers and students. Online teaching and learning tools can help to create a community of learners that is no longer limited to just one teacher and his or her students in the classroom. Depending on teaching and learning styles, a community (including experts and experienced practitioners) from outside the classroom can be introduced to the classroom and benefit both the teacher and the learners. Numerous academic and educational online communities can be accessed and included in the learning process². It takes careful planning to help students deal effectively with the many challenges of online interaction and community building. Sanders and Morrison-Shetlar (2001) reported that students had mixed perceptions about the value of being required to access and participate in chat rooms and bulletin boards as the primary community components of classes. Students generally preferred asynchronous tools to synchronous tools.

Once the first three steps are completed, the challenge is to balance the identified preferred learning and teaching styles against the advantages and disadvantages of available online instructional technology. This should be viewed as a problem-solving challenge with many potentially correct solutions.

Step 4: Select Online Teaching and Learning Tools

Considering the adoption of online instructional delivery methods may present opportunities to achieve learning objectives beyond the basic acquisition of content knowledge and/or skills such as enhancing students' levels of computer literacy. However, unless very carefully designed and implemented, different forms of instructional tools may favor students with some learning styles and technical expertise at the expense of others. Ross et al. (2001) found that

sequential learners studying computer applications using some computer-based instructional tools performed significantly better in acquisition of both skills and knowledge than did students identified as random learners. Students identified as abstract sequential in learning style performed significantly better in this study than students with any other style. Students in this study who failed the courses or withdrew were overwhelmingly identified as abstract random in style. Similarly, in another study Ross and Schulz (1999) reported that there was significant interaction between learning styles and learning outcomes. In this study students identified as abstract sequential averaged an 18% gain in learning, students identified as concrete sequential and concrete random averaged a 10% learning gain, while students identified as abstract random averaged a 10% decrease in learning. When exploring the relationships between learning styles and learning outcomes in a course instructed using computer-based instructional tools, Davidson and Savenye (1992) identified positive significant correlations between learning outcomes and abstract sequential learning styles and negative significant correlations between learning outcomes and abstract random learning styles.

Khalili and Shashaani (1994) found in their meta-analysis of computer applications for instruction that different types of computer-based instructional tools have different effects on students' learning outcomes. Carefully selected and/or designed online delivery methods may enhance learning outcomes in general but also students' levels of computer literacy and sense of efficacy when using computers as learning tools. In an age of burgeoning adoption of e-mail, e-meetings, and e-teams in the workplace, these expanded computer-based experiences may help to better emulate the new workplace. Additionally, if content is delivered in parallel forms both through traditional means and through using online tools such that students have the opportunities to learn in their preferred modes, some students may become more aware of their own cognitive processes and begin to expand the range of learning environments that they will happily work in.

The two primary indicators of the quality of

instructional tools implemented into the classroom are students' perception of the learning environment and students' learning outcomes. Using student feedback and the results from analyses of the learning outcomes enables a teacher to make decisions on what online learning activities best contribute to student learning and what framework best addresses pedagogical and technological issues. In addition, the student feedback helps to decide which online components are less liked and do not result in a positive learning experience.

One tool to help assess the effectiveness of the online tools and the quality of the combined learning environments is classroom action research. Classroom action research helps a teacher to try out new online tools, implement those that are successful, and gather student feedback, reflect, and revise to further improve and develop the course (Schmidt, 2002a).

Step 5: Reflect, Implement, Reflect, and Revise

Because this model suggests an iterative and continuous process, it will be imperative to continuously reflect, implement, further reflect on the outcomes of the implementation, and revise again the mix of online and traditional teaching and learning tools. Due to the changing nature of the online environment, only a dynamic approach to teaching and learning will maximize success.

Students' learning style preferences impact upon the quality of their attitude toward a particular instructional tool, but an instructor's consciousness of the importance of learning style preferences may help him or her to adapt tools for teaching that address the learning needs of students with multiple learning style preferences. Ross et al. (2001) recommended that one important alternative consideration when designing online instructional tools is to teach students to use strategies that will succeed in learning situations that do not favor their preferred learning style.

Conclusions

As mentioned previously, the model suggested in this article is iterative in nature. It is not intended to be a linear process leading to

selection of the best combination of instructional methods because the best combination of methods is constantly in flux. This model is rather intended to encourage continuous experimentation with both new and traditional instructional tools and methods to achieve ongoing improvement based on trial assessment and reflection of outcomes. The goal here is to attempt to improve student learning while also promoting enhanced student satisfaction levels with the learning experiences and environment.

Because this model is dynamic, it is expected that teachers will need to be open to continuous change. Students' learning styles may vary widely from student to student, new online teaching and learning tools will continue to be developed, and an increased awareness of one's teaching style will lead to modifications within the composition of online tools and classroom interaction. Only by considering these variables can a teacher continue to address students' changing learning needs in a creative, flexible, and dynamic teaching and learning environment.

Finding the right combination of online and traditional teaching and learning tools to meet

the broad array of learning styles remains one of the greatest challenges in today's teaching environment. Considering teaching and learning styles when incorporating online teaching and learning tools can help a teacher to better address student learning needs. Student learning is strongly impacted by the teacher's ability to communicate the subject matter. Creating a successful learning environment therefore heavily depends on the creativity of the teacher. It will be important to decide which course components can be enhanced most effectively via the Internet and which can be done more effectively in the traditional classroom. Only a continuous assessment of learning and teaching styles and Internet tools will help to appropriately address these issues and best meet student learning needs. We believe that in a world where lifelong learning is essential for students' long-term success, only students who experience learning in positive learning environments are likely to continue their journeys toward becoming successful lifelong learners.

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Notes

- ¹ The Grasha 5 Teaching Styles Inventory can be accessed online at <http://frc.indstate.edu/tstyles3.html>.
- ² Visit <http://www.webct.com/wyw> or <http://www.akiva.com/solutions/community.cfm>



Through interaction with digital technologies for work, play, and communication, our pattern for intellectual development is being altered. The multiple intelligences theoretical framework developed by Gardner (1983) is easily employed to provide evidence that yet another intelligence, digital intelligence, has emerged. In our postmodern pluralistic global culture, the multiple intelligences theory has enjoyed success and has impacted teaching practice. By acknowledging the existence of a new digital intelligence and all of the implications this acknowledgement may create for education and communication, we increase our ability to develop effective strategies to accommodate this new intellectual style.

Gardner (1999) encountered evidence that did not easily fit in his original model of multiple intelligences and he supposes more intelligence categories to accommodate his observations. Gardner submitted two additional distinct intelligences: moral intelligence and spiritual intelligence. He also pondered that besides these two new vessels for containment even more information has emerged that surrounds the intellectual virtuosos he described as “symbol analysts” and “masters of change.” Could these observed but unclassified characteristics be the indication of an emerging intelligence that is being fostered by human interaction with digital technologies?

Knowledge, Ways of Knowing, and Intelligence

Information is a fluid that often takes on no form until a pattern is discovered that appears to take into consideration that many possibilities for assemblage exist, but settles on the most accommodating. As with most strong models and theories, the multiple intelligences theory has defined rules for organization of information that will accommodate new evidence in such a way that will further extend the organization and therefore substantiate existing understanding and work to create new knowledge. To facilitate a discussion of intelligence, one must possess an understanding of the relationship

between knowledge, modes of knowing, and intelligence. While each has a distinct definition, all exist in an interactive relationship.

Knowledge

Knowledge can very broadly be defined as what we know or believe to exist. Many conceptions of the organization of knowledge exist. “The task of demarcating kinds of knowledge is not unlike that of demarcating different territories on a map. As there are different kinds of maps of territory, so there are different kinds of maps of knowledge” (Schrag, 1992, p. 268). Machlup (1980), in the first volume of his proposed eight volume set entitled *Knowledge: Its Creation, Distribution, and Economic Significance*, created a classification for the types of knowledge by grouping what we are able to know into discrete categories such as mundane knowledge, scientific knowledge, humanistic knowledge, social-science knowledge, and artistic knowledge. A discussion of the many knowledge classification systems is beyond the scope of this article. Machlup’s classification is mentioned to illustrate one conception of knowledge as “what we know.”

Ways of Knowing

The modes of knowing or ways of knowing endeavor to describe the human process of internalizing knowledge. Eisner (1985), in his preface to *Learning and Teaching the Ways of Knowing*, described his editing assumptions:

Since contexts change, the capacities of mind themselves alter. The roads to knowledge are many. Knowledge is not defined by any single system of thought, but is diverse. What people know is expressed in the cultural resources present in all cultures. (p. 3)

Included as topics in this collection of modes of knowing are aesthetic, scientific, interpersonal, narrative, formal, practical, and spiritual ways of knowing.

The question of what knowledge is most worthy of knowing and by which mode of

knowing this knowledge is to be internalized is often cultural but is ultimately a personal decision. Knowledge and the ways of knowing work together to create intelligence.

Intelligence

Intelligence, as defined by Gardner (1993), is “the ability to solve problems, or fashion products, that are valued in one or more cultural or community settings” (p. 7). More simply put, it is the ability of individuals to use knowledge in a personal way to successfully interact with their environment. Gardner’s definition of intelligence differs somewhat from the widely held notion that intelligence is a direct measure of knowledge. Intelligence becomes a measure of enculturation, combining knowledge and the ways of knowing with the ability to interact effectively in a cultural or community setting.

Multiple Intelligences Theory

In his original multiple intelligences classification system, Gardner (1993) defined the criteria for distinction of intelligence classes. He stated, “Each intelligence must have an identifiable core operation or set of operations. As a neurally based computational system, each intelligence is activated or ‘triggered’ by certain kinds of internally or externally presented information” (p. 16). An additional criterion was described that “an intelligence must also be susceptible to encoding in a symbol system—a culturally contrived systems of meaning, which captures and conveys important forms of information” (p. 16). Gardner contended that intelligence takes on seven domains or modes of operation. He likened intelligence to talent and outlined the following seven domains in which talent or intelligence functions: musical, bodily-kinesthetic, verbal-linguistic, interpersonal, intrapersonal, spatial, and logical-mathematical. Gardner contended that these seven intelligences reflect the way the nervous system has evolved over the millennia to yield certain discrete kinds of intelligence. He claimed that it is irrelevant whether intelligence is either inborn or learned.

Digital Intelligence — The Argument for an Additional Intelligence

No one contends that any of the original seven intelligences or the two new intelligences used for Gardner’s (1983) theoretical framework

are invalid; it is merely observed that yet another intelligence has emerged. A different intelligence, resulting from human interaction with digital computers, exists.

Classification systems are constructed around the developer’s beliefs of what knowledge is worthy of transmission. Gardner (1983) may not have held digital knowledge in the same esteem as other knowledge structures when creating his framework. As with all strong models, he did allow for the development of other intelligences. In the epilogue of *Multiple Intelligences: Theory in Practice*, Gardner (1993) foresaw “the mental landscape [of the future] might be reconfigured in light of accumulated knowledge. I have every reason to believe that the map would be drawn in a somewhat different way” (p. 250). Possibly the future is not as distant as the year 2013 that Gardner chose for prediction. In 1965, it was estimated that knowledge doubled every five years. By the year 2003, it is predicted that knowledge will double every two months. Gardner may have figured time on the 1965 scale.

Gardner’s (1993) own definition of intelligence as “the ability to solve problems or fashion products that are of consequence in a particular cultural setting or community” (p. 15) sets criteria allowing for the emergence of a digital intelligence. Our society is increasingly becoming McLuhan’s (1964) “global village.” Digital technologies have truly become an extension of man and the external neural network McLuhan described is under construction. This new intelligence is a response to the cultural change brought about by digital technologies and takes into account the skills and talents possessed by the “symbol analysts” and “masters of change” recently recognized in Gardner’s (1999) latest book. Through the development and infusion of digital technology, communication methods are rapidly expanding and taking on new forms. These technological advancements have allowed fluency across all cultures and at the same time have rapidly increased our ability for information gathering, storage, and retrieval. A new intelligence has begun to emerge—one that allows us to effectively fashion products that are of consequence in this new cultural and community setting.

Artists often describe their ability to create art as if the information or knowledge about their particular art exists in a multidimensional state in their environment. Their talent lies in their ability to decode this information and transfer it into a medium that others can more easily appreciate. This is the artists' own description of the talent or intelligence that Gardner (1983) termed musical intelligence. We have developed this type of phenomenon with information of all descriptions. We have moved it into multidimensional digital space. Information is no longer arranged in linear fashion but is now object oriented and often clustered. Because of the new functions provided through digital technologies, information/knowledge may be personally arranged and rearranged. It could be said that those with the ability to understand and interact with this digital information to arrange, manipulate, and display it according to their perceptions possess yet another intelligence—an intelligence made up of components of the other intelligences, just as musical or spatial intelligence is described by Gardner to exist. As Gardner (1999) described, there exist individual virtuosos with the characteristics of symbol analyst and master of change. Those possessing this talent could be termed digitally intelligent.

Continuing with Gardner's (1993) criteria of universality and symbol encoding system to define the existence of a discrete intelligence, there is little question of the universality of digital media across cultures. The development of computer icons used for communication within a digital environment satisfies the criterion of encoding in a symbol system. When using Gardner's own criterion for intelligence classification, digital intelligence logically exists.

Postman (1992) wrote of "the surrender of culture to technology." Slouka (1995) told with caustic humor of his initiation into cyberspace: "What I discovered, obscured by the 'noise' of the Internet, was arguably the biggest subculture in recorded history, a virtual electronic nation" (p. 43). Papert (1993) described how computers changed the fabric of my own work. What struck me most forcibly [about computers] was that certain problems

that had been abstract and hard to grasp became concrete and transparent, and certain projects that had seemed interesting but too complex to undertake became manageable. (p. 13)

These references are being made about the ability to fashion products in the form of information/communication that are of consequence in a digital culture or community.

Current literature has found a link between the multiple intelligences theory and technology. Articles outlining the uses of technology to address multimodal learning are increasing in popularity. These articles often describe the flexibility of digital technologies and prescribe specific uses of digital media to facilitate development of each of Gardner's (1993) seven currently described intelligences. Gardner described how learning to program a computer might involve multiple intelligences:

Logical-mathematical intelligence seems central, because programming depends upon the deployment of strict procedures to solve a problem or attain a goal in a finite number of steps. Linguistic intelligence is also relevant, at least as long as manual and computer languages make use of ordinary language...an individual with a strong musical bent might best be introduced to programming by attempting to program a simple musical piece (or master a program that composes). An individual with strong spatial abilities might be initiated through some form of computer graphics—and might be aided in the task of programming through the use of a flowchart or some other spatial diagram. Personal intelligences can play important roles. The extensive planning of steps and goals carried out by the individual engaged in programming relies on intrapersonal forms of thinking, even as the cooperation needed for carrying a complex task or for learning new computational skills may rely on an individual's ability to work with a team. Kinesthetic intelligence may play a role in working

with the computer itself, by facilitating skill at the terminal. (p. 390)

Gardner's description of the interaction of all of the seven intelligences with technology could lead one to conclude that digital intelligence has evolved as a meta-intelligence—one that is composed of many of the constituent intelligences.

A change in world culture caused by digital technology is occurring. Changes in communication style, life style, economic practice, and the way we think have been caused by digital technology. Our "ability to solve problems or fashion products that are of consequence in a particular cultural setting or community" (Gardner, 1993, p. 15) is directly related to our ability to interact with this emerging digital environment.

Turkle (1995) wrote:

The computer offers us both new model of mind and a new medium on which to project our ideas and fantasies...a nascent culture of simulation is affecting our ideas about mind, body, self and machine. (pp. 9-10)

The lessons of computing today have little to do with calculation and rules; instead they concern simulation, navigation, and interaction....The computer culture's center of gravity has shifted decisively to people who do not think of themselves as programmers. (p. 19)

We are moving from a modernist culture of calculation toward a postmodernist culture of simulation.... Mainstream computer researchers no longer aspire to program intelligence into computers but expect intelligence to emerge from the interactions of small subprograms. If these emergent simulations are "opaque," this is not necessarily a problem...our brains are opaque to us, but this has never prevented them from functioning perfectly well as minds. (pp. 19-20)

Healy (1990) contended changing lifestyles may be altering children's brains in

subtle but critical ways and spoke of the development of a new intellectual style. When discussing digital technology, she wrote that "subtle shifts in what the human brain is required to do will eventually cause it to modify itself for new uses" (p. 332). Her concern with this topic caused her to inquire of Dr. Jerome Bruner his opinion of changing brains in a technological age. His reply:

The only thing I can say with some degree of certainty is that the evolution of human brain function has changed principally in response to the linkage between human beings and different tool systems. It would seem as if technology and its development leads to a new basis of selection...surely there must be a variety of changes in progress that resulted from writing systems, even though writing systems were introduced only a short time ago as far as we reckon evolutionary time. And now, of course, we have computers and video systems, and how long before the selection pattern changes as a result of these? (Healy, 1990, p. 334)

McLuhan (1964) told us "the medium is the message/message" (p. 2), meaning our intelligences are shaped by the communication media we employ. Negroponte (1995) believed that our digital acumen has evolved to a point where "the medium is not the message in a digital world. It is an embodiment of it. A message might have several embodiments automatically derivable from the same data" (p. 71). He contended that our accessibility to knowledge in the form of information is becoming seemingly limitless, and with this accessibility comes the ability for us to interpret that knowledge in whichever way our intelligences need it to be interpreted.

A digital intelligence is emerging. It has rooted itself in our conceptions of knowledge and has become integrated into our ways of knowing. Intellectual skills have begun to depend upon our ability to interact in a digital environment. It is true that technology is a tool, but these digital tools have changed world culture. "An artifact pushed far enough tends to

reincorporate the user" (McLuhan & Powers, 1989, p. 3). Considerable uncertainty surrounds the impact that possession of this emerging digital intelligence will have on the future structure of our society. Such things as individual self-concept, teaching and learning practices, and organizational authority are but a few of the areas that have begun to feel the impact. The recognition and incorporation of this new intel-

ligence as a category in the multiple intelligences theory would serve to widen the inquiry into responsive teaching and learning.

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An In-Process Surface Roughness Recognition System in End Milling Operations

Lieh-Dai Yang and Joseph C. Chen

Computer numerical control (CNC) machines have been very successful in increasing productivity, repeatability, and accuracy of parts, reducing production and labor costs, and lowering operator skill in manufacturing industry (Degarmo, Black, & Kohser, 1999). In order to assure machined part quality, the operator traditionally inspects the machined parts by stopping the machine, cleaning the workpiece, and removing the workpiece from the machine table. Then, the inspection instruments are able to measure quality characteristics, such as surface roughness, inspected by a stylus profilometer. It is very time and cost consuming to conduct a quality inspection of machined parts in this manner. If there were an in-process inspection technique that could be used to measure quality characteristics of machined parts in a real-time manner without stopping the machine and removing the workpiece, productivity could be increased and time and money could be saved.

To develop an in-process quality control system, a sensor technique and a decision-making algorithm need to be applied during machining operations. Several sensor techniques have been used in the in-process prediction of quality characteristics in machining operations. For example, an accelerometer sensor was used to monitor the vibration of milling operations to develop an on-line surface roughness measuring technique in end milling operations (Chen & Lou, 1999; Jang, Choi, Kim, & Hsiao, 1996). An ultrasonic sensor was used to develop an in-process measurement of ultrasonic beams from surface roughness in milling operations (Coker & Shin, 1996). An acoustic emission sensor was used to monitor transient stress waves to estimate surface roughness in grinding (Susic & Grabec, 1995). A dynamometer sensor can be used to generate cutting forces in machining; however, the effects of surface roughness caused by cutting forces have not been taken into consideration in past research. Lee and Lin (2000) indicated that cutting forces have the most significant impact on the quality of machined parts

in end milling operations. Therefore, cutting force is to be included in developing cutting parameters affecting a surface roughness recognition system in end milling operations.

After a sensor has been selected to monitor machining operations, a proper decision-making algorithm needs to be developed to establish a recognition system by using the data collected from the sensor. Many decision-making algorithms have been developed throughout the past decade. For example, fuzzy logic, neural network, and neural fuzzy systems have been applied in the in-process surface roughness recognition (IPSRR) system (Chen & Savage, 2001; Coker & Shin, 1996; Chen & Lou, 1999, 2000; Susic & Grabec, 1995; Tsai, Chen, & Lou, 1999). Recently, a statistical approach has been effectively used for prediction, process optimization, and process control in manufacturing areas (Montgomery, 1997). For example, Fuh and Wu (1995) and Chen and Lou (1999) proposed a statistical model for surface quality prediction in end milling operations.

In this research, a multiple linear regression (MLR)-based IPSRR system using a dynamometer was applied to predict surface roughness using cutting force, spindle speed, feed rate, and depth of cut as input parameters in end milling operations.

What We Did

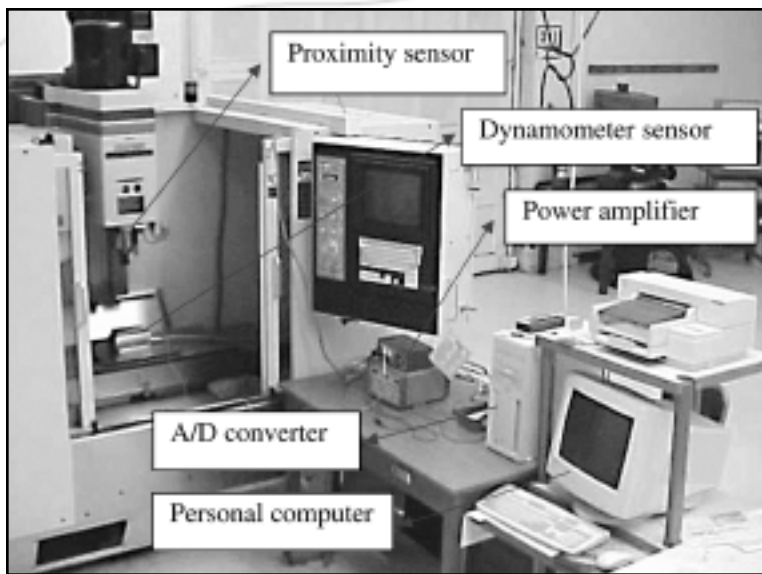
An MLR-IPSRR system was developed and implemented in two steps:

1. The magnitude of the cutting force in the end milling operation that had the highest correlation for predicting surface roughness of the finished parts was identified.
2. The MLR-IPSRR system, including the above-mentioned cutting force and cutting parameters, was developed and tested.

Procedure

Figure 1 illustrates the experimental setup consisting of the hardware and software used to accomplish the two steps.

Figure 1. Experimental setup for the proposed MLR-IPSRR system.



The hardware included:

- A Fadal vertical CNC milling machine with multiple tool changing and a 15 HP spindle.
- A Kistler 9257B type dynamometer sensor, which provided dynamic measurement of the three orthogonal components of a force signal (F_x , F_y , and F_z).
- A Micro Switch 922 series 3-wire DC proximity sensor, used to collect the signal for counting the rotations of the spindle as the tool was cutting.
- A power supplier, used to amplify the signals from the proximity and the dynamometer sensors. This amplified signal was then sent to the A/D board.
- An omega CIO-DAS-1602/12 A/D converter, used to convert both the dynamometer and proximity sensor data from analog to digital signals.
- A P5 133 personal computer, which was connected to collect data from the A/D converter output via an I/O interface.

- A 6061 aluminum workpiece with dimensions of 1.00" x 1.00" x 1.00", which was cut in the end milling operations.

In order to control end milling operations and analyze the spindle revolution and cutting force signals, the following software was required: (a) Basic CNC codes, which were applied to conduct cutting operations, and (b) A/D converter software, which was used to convert data (proximity and cutting forces) from analog signals to digital values. Using the hardware and software setups, tests of cut were performed. Figure 2 shows the data obtained from this experimental run using spindle speed ($S = 2500$ rpm), feed rate ($F = 8$ ipm), and depth of cut ($D = 0.08$ in.).

The Cutting Forces Analysis

From Figure 2, the cutting force data were collected from the dynamometer sensor; these three forces (F_x , F_y , and F_z) cannot individually represent the actual force affecting surface rough-

Figure 2. Proximity and cutting force digital data using cutting condition $S = 2500$ rpm, $F = 8$ ipm, and $D = 0.08$ in.

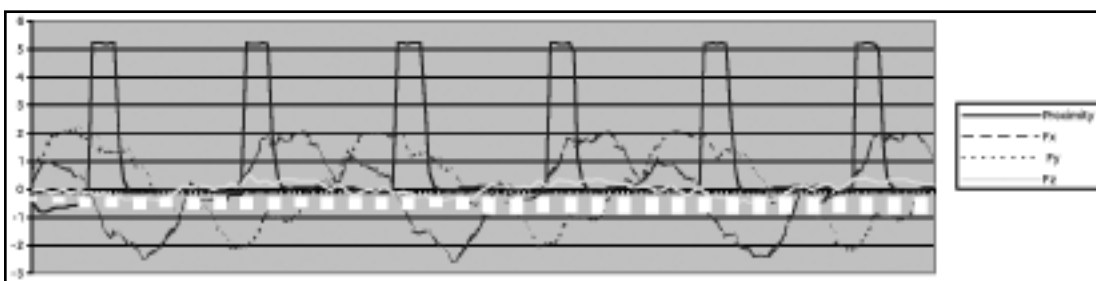
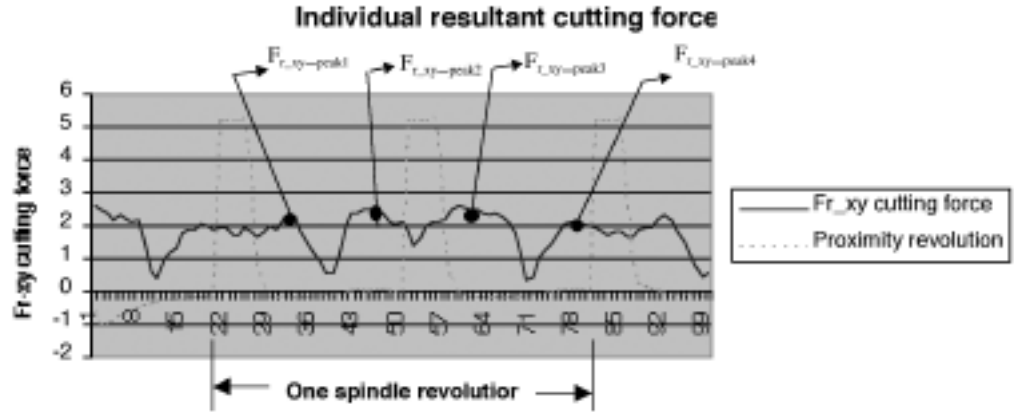


Figure 3. Individual resultant cutting force $F_{r,xy}$ and four peak forces in one revolution at cutting condition of $F = 20$ ipm, $S = 2000$ rpm, $D = 0.08$ in.



ness. Four cutting force magnitudes ($\overline{F}_{r,xy}$, \overline{F}_{r,xy_peak} , \overline{F}_z , and $\overline{F}_{r,xyz}$) were considered as possible candidates for an input factor for the MLR-IPSRR system. They are defined as:

1. Average resultant force of the x and y directions per revolution ($\overline{F}_{r,xy}$).

By using the following equation, one could find the individual resultant force ($F_{r,xy}$) from the x and y directions as shown in Figure 3.

$$F_{r,xy,i} = \sqrt{F_{x,i}^2 + F_{y,i}^2}, \quad (1)$$

where i is the data point in one revolution.

Then, the average resultant force in one revolution ($\overline{F}_{r,xy}$) could be given as:

$$\overline{F}_{r,xy} = \frac{\sum_{i=1}^m F_{r,xy,i}}{m}, \quad (2)$$

where $i = 1, 2, \dots, m$ and m is the total data points in one revolution.

2. Average resultant peak force (\overline{F}_{r,xy_peak}).

By using the data shown in Figure 3, one could also identify the peak force (F_{r,xy_peak}) from the average resultant forces of the x and y directions ($\overline{F}_{r,xy}$) in the cut period of each tooth. Then, the average resultant peak force in each revolution (\overline{F}_{r,xy_peak}) could be given as:

$$\overline{F}_{r,xy_peak} = \frac{\sum_{i=1}^r F_{r,xy_peak,i}}{r}, \quad (3)$$

where $i = 1, 2, \dots, r$ and r is the number of cut-

ting tool teeth. In this study, $r = 4$.

3. Average z direction cutting force per revolution (\overline{F}_z).

The third type of force analyzed in this study was the average cutting force in the z direction per revolution (\overline{F}_z) and could be given as:

$$\overline{F}_z = \frac{\sum_{i=1}^m F_{z,i}}{m}, \quad (4)$$

where $i = 1, 2, \dots, m$ and m is the total data points in one revolution.

4. Average resultant force of x, y, and z directions per revolution ($\overline{F}_{r,xyz}$).

The researcher also wanted to analyze the average resultant force of the x, y, and z directions in one revolution ($\overline{F}_{r,xyz}$). The force is given as:

$$F_{r,xyz,i} = \sqrt{F_{x,i}^2 + F_{y,i}^2 + F_{z,i}^2}, \quad (5)$$

where i is the data point in one revolution.

Then, the average resultant force in one revolution ($\overline{F}_{r,xyz}$) could be given as:

$$\overline{F}_{r,xyz} = \frac{\sum_{i=1}^m F_{r,xyz,i}}{m}, \quad (6)$$

where $i = 1, 2, 3, \dots, m$ and m is the total data points in one revolution.

After the above-mentioned cutting forces were formed, we examined the correlation coefficient between these cutting forces and surface roughness. Equation 7 was used to compute the

correlation coefficient between surface roughness (Ra) and the average resultant force of the x and y directions ($\bar{F}_{r,xy}$).

$$\rho_{Ra-\bar{F}_{r,xy}} = \frac{\sum_{i=1}^n (Ra_i - \bar{Ra})(\bar{F}_{r,xy,i} - \bar{\bar{F}}_{r,xy})}{\sqrt{\sum_{i=1}^n (Ra_i - \bar{Ra})^2 \sum_{i=1}^n (\bar{F}_{r,xy,i} - \bar{\bar{F}}_{r,xy})^2}} \quad (7)$$

where $\rho_{Ra-\bar{F}_{r,xy}}$ is the correlation coefficient between the average resultant cutting force ($\bar{F}_{r,xy}$) and surface roughness, Ra_i is the i th surface roughness, $i = 1, 2, \dots, n$ (n is total data sets; here $n = 384$), and $\bar{F}_{r,xy,i}$ is the i th average resultant cutting force of the x and y directions, $i = 1, 2, \dots, n$, (n is total data sets; here $n = 384$).

$$\bar{Ra} = \frac{\sum_{i=1}^n Ra_i}{n}, \quad \bar{\bar{F}}_{r,xy} = \frac{\sum_{i=1}^n \bar{F}_{r,xy,i}}{n}$$

Similarly, $\rho_{Ra-\bar{F}_z}$ and $\rho_{Ra-\bar{F}_{r,xyz}}$ were calculated. The largest value of correlation coefficients between the above-mentioned cutting forces and surface roughness represented the most significant cutting force, which was then used in the development of the MLR-IPSRR system.

Experimental Design

In order to identify the most significant cutting force for the MLR-IPSRR system, an experimental design matrix was used to run and collect the training data. The experimental design matrix, including eight levels of feed rate (6, 8, 10, 12, 14, 16, 18, and 20 ipm), four levels of spindle speed (1750, 2000, 2250, and 2500

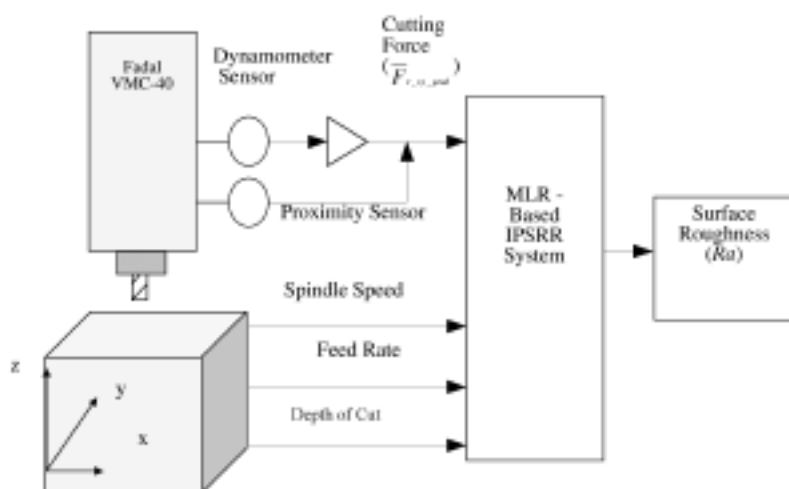
rpm), and three levels of depth of cut (0.04, 0.06, and 0.08 in.), was designed for the experiments with two replicates of each experiment. Two end milling tools (1/2 in. with four teeth) were used to cut the workpiece. Therefore, a total of $8 \times 4 \times 3 \times 2 \times 2 = 384$ sets of training data were collected. Cutting forces (F_x , F_y , and F_z) were collected using a dynamometer, as shown in Figure 1. The average resultant force of the x and y directions ($\bar{F}_{r,xy}$), average resultant peak force ($\bar{F}_{r,xy,peak}$), average cutting force of the z direction (\bar{F}_z), and average resultant force of the x , y , and z directions ($\bar{F}_{r,xyz}$) were calculated using Equations 2, 3, 4, and 5.

The 384 specimens were measured offline with a Pocket Surf stylus type profilometer (produced by Federal Products Co.) to obtain surface roughness (Ra) in this study. A JMP (a product of the SAS Institute) statistical software package was used to calculate the correlation coefficient between surface roughness and cutting forces. The results were $\rho_{Ra-\bar{F}_{r,xy}} = 0.49$, $\rho_{Ra-\bar{F}_{r,xy,peak}} = 0.53$, $\rho_{Ra-\bar{F}_z} = 0.46$, and $\rho_{Ra-\bar{F}_{r,xyz}} = 0.43$; therefore, the average resultant peak force of the x and y directions ($\bar{F}_{r,xy,peak}$) had the highest correlation coefficient with surface roughness and was selected as the input parameter for the MLR-IPSRR system.

The Proposed MLR-IPSRR System

After the most significant force was identified, the MLR-IPSRR system shown in Figure 4 was proposed. From Figure 4, one can see the

Figure 4. The structure of the proposed MLR-IPSRR system.



input parameters (average resultant peak force [$\bar{F}_{r_{xy_peak}}$], spindle speed [S], feed rate [F], and depth of cut [D]) and the output parameter (surface roughness [Ra]) used to generate the MLR-IPSRR system. The proposed MLR-IPSRR system is given as:

$$\begin{aligned} Ra_i = & \beta_0 + \beta_1 F_i + \beta_2 S_i + \beta_3 D_i + \beta_4 \bar{F}_{r_{xy_peak}} \\ & + \beta_{12} F_i * S_i + \beta_{13} F_i * D_i + \beta_{14} F_i * \bar{F}_{r_{xy_peak}} \\ & + \beta_{23} S_i * D_i + \beta_{24} S_i * \bar{F}_{r_{xy_peak}} \\ & + \beta_{34} D_i * \bar{F}_{r_{xy_peak}} + \beta_{123} F_i * S_i * D_i \\ & + \beta_{124} F_i * S_i * \bar{F}_{r_{xy_peak}} + \beta_{234} S_i * D_i * \bar{F}_{r_{xy_peak}} \\ & + \beta_{1234} F_i * S_i * D_i * \bar{F}_{r_{xy_peak}} + \varepsilon_i \end{aligned}$$

where β are coefficients of the regression model, Ra_i is the surface roughness, F_i is the feed rate, S_i is the spindle speed, D_i is the depth of cut, $\bar{F}_{r_{xy_peak}}$ is the average resultant peak force of the x and y directions, and $\varepsilon_i \sim N(0, \sigma^2)$, where i is the number of data sets. To obtain data for the development of a multiple regression prediction model, a total of 384 experimental runs have taken place using the cutting combination indicted in the experimental design section. Therefore, in this study, $i = 1, 2, 3, \dots, 384$.

Analysis and Results of the System

After utilizing the JMP software package, the results of the surface roughness MLR model were generated as follows:

$$\begin{aligned} Ra_{(predicted)} = & 57.066 - 0.024 * S + 4.142 * F - \\ & 0.001 * (S - 2125) * (F - 13) + 491.056 * D + \\ & 0.630 * (S - 2125) * (D - 0.06) + 41.820 * (F - \\ & 13) * (D - 0.06) - 0.351 * \bar{F}_{r_{xy_peak}} - 0.0007 * \\ & (S - 2125) * (\bar{F}_{r_{xy_peak}} - 75.787) + 0.015 * \\ & (F - 13) * (\bar{F}_{r_{xy_peak}} - 75.787) - 0.326 * \\ & (D - 0.06) * (\bar{F}_{r_{xy_peak}} - 75.787) + 0.099 * \\ & (S - 2125) * (F - 13) * (D - 0.06) - 0.0001 * (S - \\ & 2125) * (F - 13) * (\bar{F}_{r_{xy_peak}} - 75.787) + 0.01 * \\ & (S - 2125) * (D - 0.06) * (\bar{F}_{r_{xy_peak}} - 75.787) + \\ & 0.722 * (F - 13) * (D - 0.06) * (\bar{F}_{r_{xy_peak}} - 75.787) \\ & - 0.0016 * (S - 2125) * (F - 13) * (D - 0.06) * \\ & (-\bar{F}_{r_{xy_peak}} - 75.787) \end{aligned}$$

The effect of tests showed that the feed rate, spindle speed, average resultant peak force, and depth of cut influenced the surface roughness significantly since the p values of each main effect (feed rate, spindle speed, average resultant peak force, and depth of cut) were less than a =

0.01 significant level). That is, the surface roughness was mainly determined by the feed rate, spindle speed, average resultant peak force, and depth of cut in end milling operations. The MLR model was also significant with the p value less than $\alpha = 0.01$. Therefore, the MLR model can be effectively used in this research.

Once the MLR model had been established, the MLR recognition model was tested using 20 sets of cutting conditions that were different from the cutting conditions of experimental designs. The MLR-IPSRR model was implemented in the prediction of the surface roughness while the machining process was taking place. The results of the predicted surface roughness (Ra_i^{MLR}) were compared with the finished parts (Ra_{i-m}) that were measured by using a Pocket Surf portable surface roughness gauge. Then, the individual precision Φ_i^{MLR} of each experimental run (i) was evaluated based on the following equations.

$$\Phi_i^{MLR} = 1 - \frac{Ra_i^{MLR} - Ra_{i-m}}{Ra_i} \quad (8)$$

$$\bar{\Phi}^{MLR} = \frac{\sum_{i=1}^{20} \Phi_i^{MLR}}{20} \quad (9)$$

where Φ_i^{MLR} is the precision of i th testing run, and $\bar{\Phi}^{MLR}$ is the average precision of the 20 testing data, $i = 1 \dots 20$.

The results showed that the capability of the surface roughness prediction was about 86% for the testing experimental data in this study. Therefore, one can see that the surface roughness (Ra) can be predicted effectively by the above-mentioned MLR-IPSRR system.

What We Learned

The purpose of this study was to analyze cutting forces to find out the most significant cutting force magnitude that affected surface roughness and to evaluate whether a MLR approach for surface roughness recognition could be used for prediction in the IPSRR system. Our main conclusions are summarized as follows:

- The average resultant peak force ($\bar{F}_{r_{xy_peak}}$) was identified to be the most significant force to affect surface roughness in this study.

- Spindle speed, feed rate, average peak cutting force, and depth of cut are significant in affecting surface roughness in end milling operations and the determination of the coefficient is R^2 of 0.62 in the MLR model.
- The MLR-IPSRR system is approximately 86% accurate in predicting surface roughness while the machining process is taking place.

This research assumed that the CNC milling machine was effective and stable to conduct all experiments under each cutting condition using an HSS end mill to cut 6061 aluminum material. We believe that the proposed IPSRR system could eventually be implemented in the new age of CNC machines. This would be more likely if additional research and testing could be done such as (a) including different

tool material, tool radius, workpiece material, and lubricants in the system and (b) using different methodologies, such as fuzzy logic, neural networks, and fuzzy nets, to provide the IPSRR system with a learning capability. With this capability, the system could be adopted to different machines produced from different CNC manufacturers.

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Silicon Valley's Processing Needs Versus San Jose State University's Manufacturing Systems Processing Component: Implications for Industrial Technology

Samuel C. Obi

Background and Rationale

Manufacturing professionals within universities tend to view manufacturing systems from a global perspective. This perspective tends to assume that manufacturing processes are employed equally in every manufacturing enterprise, irrespective of the geography and the needs of the people in those diverse regions. But in reality local and societal needs influence the manufacturing processes employed by a region's manufacturers. To design better and more useful curricula that meet local needs, manufacturing systems professors and administrators need to understand the nature and magnitude of this issue.

Material processing is a major component of manufacturing systems (Seymour, 1995). All manufacturing programs emphasize material processing as a major component of their curricula. However, manufacturing processing needs in one geographical locality are often different from the needs in others. For example, while manufacturing companies in the mid-western and western United States may share commonalities in some processes, the differing needs of the two populations can result in companies of one locality emphasizing one or more processes more than the other, and vice versa. When such a situation exists, it is the responsibility of manufacturing educators and administrators to determine what changes are needed in their curricula to reflect local needs and what the local industry is doing. In other words, manufacturing processes employed by companies in a location are reflections of what manufacturing students in that location need to learn. This is important because most of their graduates get employed by companies located in that region. Addressing these regional differences in manufacturing process utilization constitutes the rationale for this study

To investigate how this applies to the manufacturing systems curriculum at San Jose State University (SJSU), a case study was undertaken in the spring of 2002. The results are contained

in this article, which examines the processing needs of manufacturers in the Silicon Valley of Northern California and compares the findings with the contents of SJSU's manufacturing systems program.

Procedure

This study was undertaken in two phases. The first phase determined which manufacturing processes generated more activities in the Silicon Valley of Northern California, as evidenced by the frequency of their use in the commercial advertising by the region's job shop manufacturers. An underlying assumption was that the frequency of use in a major advertising publication was an indication of the need and popularity of a process. To accomplish this, a special group of manufacturers was selected as the main population. This group included all the commercial and professional job shop manufacturers who participated in the 2001 and 2002 Job Shop Shows at the Santa Clara Convention Center. This annual, three-day business-oriented event is billed by its sponsors as the Southwest's largest contract manufacturing event ever. It attracts hundreds of manufacturing-related companies each year. These companies advertised numerous manufacturing processes as services that they provided, ranging from rubber forming to stamping and machining. The companies, together with their services, are published in the Job Shop Technology magazine, a quarterly publication serving manufacturers in the Silicon Valley (Short, 2001, 2002). These advertised processes were identified, sorted, and collated to determine their frequencies to help identify the advertised manufacturing processes that generated more or less activities among the job shops in the Silicon Valley region.

A total of 42 processes, together with their respective frequency scores for 2001 and 2002, were so identified. They included: brazing (4, 4); chemical etching (1, 3); coating (3, 4); deep drawing (3, 3); die casting (8, 9); die cutting (1, 4); EDM (7, 11); electroforming (2, 3); elec-

tron beam welding (1, 1); extrusion (12, 10); finishing (3, 8); grinding (3, 5); heat treating (2, 3); hydroforming (2, 1); injection molding (7, 13); investment casting (3, 1); laser cutting/drilling (5, 9); laser etching (2, 1); laser marking (4, 5); laser welding (2, 3); machining (42, 44); mold design (6, 1); molding (0, 2); perforating (1, 1); photochemical machining (3, 9); plating (4, 6); powder coating (2, 2); punching (1, 2); roll forming (0, 1); rubber molding (9, 8); sand casting (0, 1); sheet metal fabrication (6, 3); sheet metal forming (1, 5); springs (10, 11); stamping (18, 22); thermoforming (2, 2); thread rolling (0, 1); tooling design/fabrication (2, 5); tube bending (1, 1); water jet cutting (3, 3); welding (2, 9); and wire forming (9, 5). Processes that received a score of 5 or higher were given more attention in this study

The second phase of the study determined the degree to which SJSU's related manufacturing systems processing courses addressed these advertised processes. The premise here is that whatever is practiced by the manufacturing companies (which is an indication of what the society needs) is, to some degree, a reflection of what should be taught (Obi, 1991). To accomplish this, SJSU's manufacturing systems' key material processing courses were identified. They included: Tech 20 (Computer-Aided Design); Tech 046 (Introduction to Machining Processes); Tech 103 (Industrial Materials); Tech 104 (Manufacturing: Planning and Processes); Tech 142 (Product Prototyping and Manufacturing); Tech 143 (Polymers and Composites Fabrication Technology); and Tech 144 (Computer-Aided Manufacturing). The courses were then matched with their related processes according to their respective contents. This helps in visualizing processes that received coverage and those that did not, a picture that would help professors and administrators to make appropriate corrections if need be.

Findings and Discussions

The study revealed several observations:

- (a) one process received too much coverage,
- (b) some processes were covered adequately,
- (c) some processes received too little coverage,
- (d) some processes were not covered at all in the program, and
- (e) some processes were not

advertised but were taught in the program.

These processes and comments essentially constitute the findings from this study and are discussed in the following paragraphs.

It is encouraging to note that only one process (sand casting) appeared to be receiving too much coverage in the manufacturing systems concentration at SJSU. Perhaps this was because manufacturers now increasingly employ other casting processes. In fact, some casting processes such as die casting and shell mold casting have actually gained more popularity and use in recent years than other more traditional techniques such as sand casting. Fortunately, only one course (Tech 142) has a significant sand casting content. Perhaps, SJSU's manufacturing systems professors should switch to an alternative casting process to reflect current trends and help address this problem. If this happens to be the case, then consideration must be given to such factors as cost of die casting equipment, ease of maintenance, space availability, and so forth.

It was also encouraging that the study indicated adequate coverage of 25 (or about 60%) of the 42 processes advertised, including brazing, chemical etching, coating, deep drawing, die cutting, EDM, electron beam welding, finishing, grinding, heat treating, injection molding, investment casting, laser welding, machining, mold design, molding, perforating, punching, roll forming, sheet metal fabrication, sheet metal forming, thread rolling, tooling design/fabrication, water jet cutting, and welding. However, students received significant practical experience performing grinding, injection molding, machining, sheet metal fabrication, and tooling design/fabrication in courses containing those processes. But lectures, videos, and field trip activities alone provided enough learning experience for students in courses containing processes that received low advertising frequencies, since they are not considered to be high-demand processes.

On the other hand, the study indicated that eight processes received little coverage in SJSU's manufacturing systems program: die casting, extrusion, laser cutting/drilling, photochemical machining, plating, rubber molding,

stamping, and wire forming. Little coverage here means that these processes are covered only in classroom lectures, which does not match the high frequency scores received by the processes. Although the lectures often include videos and field trips, the actual performance of the process by students (a critical component of technology education) is missing. The absence of this applied component in a manufacturing systems program renders its graduates ill prepared to perform effectively when they enter the workforce. These graduates are expected to supervise working people and processes. A good familiarity with the processes that they will supervise will help equip them with the critical knowledge and skill needed in today's industrial environment.

Correcting this problem could require significant investment in equipment, space, and training, something SJSU's administrators are not willing to do because of their limited budget. But this is a problem that SJSU's manufacturing professors have to deal with in order to help meet those challenges and improve their manufacturing systems program. Therefore, some creative approach may have to be employed to address the problem. One possible idea is to help students complete their internships in companies where those processes are performed so they can learn those skills. Another idea may be to recommend that manufacturing systems students take courses containing those processes in a junior college and then transfer them to SJSU.

Of the eight processes that received no coverage at all in the program, namely, electroforming, hydroforming, perforating, plating, powder coating, spring forming, tube bending, and wire forming, only plating, spring forming, and wire forming are of major concern to the program because the rest did not receive as high scores as these three did. The processes that received lower scores can be included in lectures. But to implement plating, spring forming, and wire forming will again require significant investment in equipment, space, and training. Therefore, a possible solution here will be the industrial internship and junior college credit transfer ideas already discussed above.

The case of missing processes is the last observation to be mentioned here. These are processes that were not advertised by the participating companies but are taught in the program. Slush casting and open die forging, for example, were not advertised by the companies but are discussed in lectures at SJSU's manufacturing systems program. Such a situation may be due to a number of reasons, such as the case with a government contractor on specialized processes, a small business that cannot afford to participate in the show, a business whose process may not be needed locally, or simply a business that usually gets enough customers and does not care or want to participate in the job shop show. SJSU's professors and others in such a situation should use their judgment in configuring their curriculum to match companies' needs, especially if those same companies are also area employers.

It should also be mentioned that the view taken in this study represents only manufacturing-related entities that *actually* advertised their services in the job show. One should not interpret this group to represent all manufacturing companies in the Silicon Valley. Therefore, any major decisions made by SJSU's manufacturing systems professors and administrators from the results of this study should be made after other factors are considered. Such factors might include the robustness of the program, currency of the curriculum, enrollment trends in the program, and the general opinions about the program content as expressed by stakeholders such as students, parents, industry personnel, and other educators, especially community college instructors.

Implications for Manufacturing and Industrial Technology Programs

This case study was an attempt to determine the processing needs of Silicon Valley's manufacturers and compare them with the manufacturing systems processing component at SJSU. It also shows how the findings could be employed to reconfigure the curriculum to reflect local needs.

As has been demonstrated in the foregoing discussions, this kind of study helps educators and administrators to visualize the content mat-

ter of their programs more precisely and then determine whether they are meeting their intended goals and objectives. In other words, it acts as a tune-up whenever educators are in doubt about what they should be teaching. It also acts as a check and balance for a program. Since curriculum development is the core function of education, ensuring that essential and appropriate materials are covered in a program is critically important if manufacturing systems graduates are to be competently knowledgeable when they enter the workforce. This practice more directly affects the students and graduates of the region where the programs are located. Designing program content to reflect the industrial tasks of the area will certainly be a plus for the graduates and the manufacturing organizations that hire them when they graduate.

Also, this practice essentially makes the programs more functional in the communities that they serve. Students in such programs will more easily relate to the manufacturing jobs

advertised in their locality when they see one. And program educators and job providers will tend to be working together toward a common goal, since they can now see their commonality more easily. The result is that the manufacturing programs in the region will be more robust and the graduates more educated.

Finally, this study is recommended for all manufacturing programs, not only to help visualize how different localities and economies influence the manufacturing processes of their respective locations but also to ensure that the needs of students and employers in such regions are being met. It potentially can result in stronger manufacturing systems programs that will be in business for many years to come.

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Creative and Collaborative Problem Solving in Technology Education: A Case Study in Primary School Teacher Education

Jari Lavonen, Ossi Autio, and Veijo Meisalo

Many public and private institutions believe that there is a growing need for employees who are able to think creatively and solve a wide range of problems (Grabinger, 1996). On the

other hand, several researchers have maintained that many of the skills and competencies needed in working life are seldom obtained at school (e.g., Resnick, 1986). Therefore, competency-

based or performance-based approaches to teacher education have been recommended in order to give students a broader perspective and to equip them to teach technology (Custer, 1994; Sinn, 1996; Whitty & Willmott, 1991). In particular, it has been argued that creative problem solving is an integral part of technology education, in contrast to an instruction-following method of technology education, reproducing artifacts, and teacher-dominated work (De Luca, 1993; Sellwood, 1991; Williams & Williams, 1997). Wu, Custer, and Dyrenfurth (1996) suggested even more forcefully that (creative) problem solving should be a core content area and method of teaching technology. These approaches particularly seem to fit technology-oriented modules in teacher education.

In this article, the Creative Technology Education Project (CTEP) is presented, and phases of problem-solving processes in which the participating primary school student teachers generate alternatives and evaluate ideas are analyzed. The aims of this project were to introduce technology education goals and contents to these students, as well as to offer tools for learning and teaching technology, and to facilitate personal growth. One purpose of the project was to encourage the students to become familiar with technology and problem-solving processes and to develop especially creative skills and abilities (e.g., ideation and the evaluation of ideas). For those purposes, a model was introduced, named the Overall Mapping of a Problem Situation (OMPS). This model helps students in ideation (the generation of alternative solutions) and evaluation of ideas when working on project teams. This model was practiced with concrete technology education projects. Thus, the project focus was on collaborative problem solving, with special emphasis on ideation and the positive evaluation of ideas.

Creative and Collaborative Problem Solving

Different ways to emphasize creative problem solving in small groups have been suggested (e.g., Dooley, 1997; Grabinger, 1996; Hill, 1999). A common feature of these approaches is to place students in the midst of a realistic, ill-defined, complex, and meaningful problem with no obvious or correct solution. Students work in

teams, collaborate, and act as professionals, confronting problems as they occur – with no absolute boundaries. Although they get insufficient information, the students must settle on the best possible solution by a given date. This type of multistaged process is characteristic of effective and creative problem solving. These stages may include (a) formulating the problem, (b) recognition of facts related to the problem, (c) goal setting, (d) ideation or generating alternatives, (e) the evaluation of ideas, (f) choosing the solution and, (g) testing and evaluating (De Luca, 1993; Fisher, 1990; Welch & Lim, 2000). The process is nonlinear and follows no particular rules because rational approaches miss the entire point of creative problem solving.

In accordance with Hennessy and Murphy (1999), the term collaboration is used in this article to describe social interaction within a group or a team, when students actively talk and share their cognitive resources, working together to produce a single outcome. They are also supposed to establish joint goals and referents, making joint decisions, solving emerging problems, constructing and modifying solutions, and evaluating the outcomes through dialogue and action. Collaboration requires students to actively communicate (e.g., negotiate or debate) and work together (e.g., set goals, plan, generate alternatives) with the aim of producing a single outcome (e.g., an object, a computer program, or a technological process/system). The students must then evaluate their outcome through dialogue and action (Hennessy & Murphy, 1999).

When problem solving is creative, the ideas or products produced during the problem-solving process are both original and appropriate (Fisher, 1990). For these purposes, various idea-generation techniques or ideation models are valuable (Smith, 1998). The number of alternative solutions is important because the best way to come up with good ideas is to have plenty of choice (Parker, 1991). Consequently, the outcome of creative problem-solving activities depends largely on the creative processes and ideation techniques that have been learned and applied. Furthermore, there are factors of attitude (interest, motivation, and confidence), cognitive ability (knowledge, memory, and thinking-skill), and experience (familiarity with con-

tent, context, and strategies) that influence problem-solving processes (Fisher, 1990). For example, nonjudgmental positive feedback and the acceptance of all ideas, even absurd or impractical ones, are important in all creative group processes for generating significant alternatives (Higgins, 1994). There should be room for free ideation sessions. Evaluative critiques should only take place afterwards.

Numerous models for curriculum changes in technology education, as well as for introducing creative problem-solving processes, are available nowadays in both technology education literature and school textbooks (Johnsey, 1995). Nevertheless, there still appears to be an overemphasis on passive learning and the old traditions of craft learning (Kimbell, 1997). Moreover, some renewed curriculum models lead easily to a situation in which the construction phase immediately follows the planning phase, without enough time for conceptualization, ideation, and the evaluation of ideas (Alamäki, 2000; Elmer & Davies, 2000). An especially important aspect of technology education and teacher education is providing the opportunity to get away from routine activities and low-level thinking so that students can find fresh new ideas and approaches, for example, by utilizing group dynamics or special creative methods (Smith, 1998).

There is an obvious need for young technology teachers to act as agents for change. Moreover, it is obvious as well that more research and development effort should be directed towards introducing creative problem-solving approaches in technology education (Gilbert & Boulter, 2000; Lee, 1996). Instruction and teaching models experienced during primary school teacher education often serve as learning models for students. The plan of the CTEP, described in more detail below, was based on the assumption that collaborative and creative problem solving would be valuable for developing a premium technology education study module for primary school teacher education. The purpose of the study presented in this article was to discover how students perceive the creative process and to what extent they learn creative skills, especially those that involve generating alternative ideas and the self-

evaluation of these alternatives.

The following questions guided this study:

1. What are the key factors in creative problem-solving processes from the point of view of primary school student teachers?
2. Have students learned creative skills during their enrollment in the CTEP?

The CTEP

The practical goal of the CTEP was to introduce student teachers to the OMPS method and to help them to become familiar with problem-solving processes, ideation techniques, and evaluation of ideas.

Of the 118 participating students, 80% were female and were on average 24 years old. According to the collected background information, 77% of the students had little or no previous knowledge or experience regarding the contents and methods of technology education. Less than 10% of them, however, disagreed with statements indicating high motivation and responsibility in their work, as well as success in planning and collaboration during the CTEP. Only about 15% of the participating students thought that the CTEP was of little significance to the primary school teaching profession or that the CTEP offers little that is applicable to their profession. It can be concluded, therefore, that the students' attitudes to the project were largely positive and that they agreed with the project goals.

At the beginning of the CTEP, the students attended four hours of lectures and demonstrations about creative problem solving. The sessions covered different idea generation techniques, such as brainstorming and analogous thinking. In addition, the students became familiar with the theme through WWW pages (Lavonen & Meisalo, 2001) that presented problem-solving models and a couple of idea-generating techniques, such as the OMPS (Sellwood, 1991). Different (e.g., creative, social, and personal) abilities and skills needed in creative problem solving, as well as ways to establish a creative and open atmosphere, were discussed. After the above-mentioned sessions, a four-hour workshop was organized in which the students worked in small groups. In these workshops,

Figure 1. An example of a planning process expressed by a map constructed during the creative phase. In this phase, the primary school student teachers utilized the OMPS-method.

The Problem: How to design a coaster for a coffee-pot in a creatively different way.			
Facts: - should insulate - be used on a table - 20 hrs to plan and make it - ...	Opinions: - beautiful coaster - always on display - wooden - not big - recycling materials	Goals: It should be - useful - easy to move - modern - ...	Visions: - Ideal for Y2K - Artistic
Approach A: interesting shape Idea A1: oval + traditional + easy to turn on the lathe + beautiful ? how to avoid familiarity ? how to inspire makers Idea A2: triangle + cups can be placed in the corners + innovative + interesting + easy to make from wood ? how to stack Idea A3: star... + ...	Approach B: coaster with layers Idea B1: two layers + kettle holder underneath + innovative + interesting ? how to prevent keeling over Idea B2: three feet and hooks for cups + innovative + interesting + can be moved with one hand ? how to prevent keeling over Idea B3: a candle can warm the coffee-pot from below + ...	Approach C: integrated tray and coaster Idea C1: big wooden construction + practical as tableware + innovative + can be given as a present + embellishment for the table ? how to manage in time Idea C2: double heart + ... + ... + ... ? ... Idea C3: ... + ...	Approach D: box... Idea D1: tea bags in the coaster + easy to find + gift + innovative ? ... Idea D2: spice-rack integrated with the coaster + ideal for a party + easy to clean the table + ... ? how to manage in time Idea D3: ... + ...

students became familiar with the OMPS method by using it to plan a bridge or tower to be constructed out of newspapers.

During the planning phase of the project (four to eight hours), the groups of 3 to 4 students worked in 24 collaborative teams according to the basic principles of the OMPS method and generated a map of the creative process (see Figure 1). First, the students had to find, formulate, and specify the problem (*How could something be done differently?*) and recognize the facts (agreed by the team) and opinions related to the problem. Next, the teams set the problem or team assignments in a cogent phrase, such as: *How can an interesting electric toy be constructed differently? or How can a game be designed differently?* In addition, the students had to set the goals and visions (ideal performance). Then, the students had to create suitable approaches for solving the problem and to generate problem-solving alternatives. Every alternative idea was subsequently backed up by presenting at least three reasons for its adoption. Nonjudgmental positive feedback and the acceptance of all ideas, even absurd or impractical ones, were held as important rules during all

group processes that generated creative alternatives (Higgins, 1994). During the planning phase, the teams identified, on average, 3.8 (SD = 1.30) facts and expressed 2.1 (SD = 1.6) opinions related to the problem. The teams set, on average, 2.7 (SD = 1.0) goals and created 1.9 (SD = 1.2) visions. They generated, on average, 3.4 (SD = 0.59) problem-solving approaches and 7.3 (SD = 2.4) ideas as to how to solve the problem. In the subsequent maps, there were 13.6 (SD = 7.7) positive evaluations of the presented ideas and 3.9 (SD = 3.4) constructive “how” questions. Some teams presented their ideas in figures.

During the creative process, it was also possible to ask constructive questions about the idea or to combine, redefine, and piggyback ideas. After generating dozens of ideas, students chose the most appropriate solution by comparing the positive feedback and constructive questions that related to each idea. Typically, the final solution was a combination of several original ideas. During the ideation phase, the students were encouraged to follow the creative rules and to utilize idea generation techniques while working in collaborative groups. After

selecting the final ideas, students then planned out how they would construct the structure or perform the process.

After generating alternatives, evaluating them, and designing and planning the project, the students created something new in their design solution process utilizing paperboard, wood, metal, and/or plastic and the appropriate tools. The teams spent approximately 12 hours in the workshop and worked according to their previously agreed plans. It was intended that the students should be creative in their teams and that they would modify their preliminary plans during the practical work period. Finally, each team presented their innovations to the other groups and evaluated both the innovations and the entire process, first by themselves and then with the others. The construction and evaluating phases are not included in this article.

Implementation of the Study

This research can be described, in accordance with Stenhouse (1985), as exploratory evaluation research, in which data were gathered to evaluate the CTEP described above. It is a typical case study in which different approaches to data gathering is used, including gathering data in numerical form. Moreover, the study also has features of developmental research, which Richey and Nelson (1996) defined as a systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness.

For evaluating the creative problem-solving processes, a questionnaire consisting of 23 items was utilized, thereby yielding self-evaluative data concerning the students' success as regards the conceptualization and evaluation of ideas, as well as on their success with creative problem solving. The items were formulated on the basis of theoretical ideas about features of creative problem-solving processes presented in the theoretical framework of this article. For each Likert-type item, there were five alternatives, varying from *strongly disagree* (1) to *strongly agree* (5). The questionnaire included some items about the students' background as well as items about their motivation and general success during the teaching experiment.

The items were located randomly in the questionnaire, which was accessible over the Internet, and the students were asked to fill in the forms after the last meeting. Eighty-five students out of the 118 students who participated in the project answered the questionnaire. A preliminary item analysis based on item-to-item correlations and item-to-total score correlations led to the elimination of four of the questionnaire items. For example, the item *I learned to support the self-respect of other students* only had a 0.15 correlation to the total score and was, therefore, rejected from the final analysis. It is obvious that the students must have misunderstood the rejected items or that the items were ambiguous. On the other hand, it is also possible that the students did not agree with the rejected items. The internal reliability of the remaining 19 items was high (Cronbach alpha = .89).

An exploratory factor analysis was used to reduce the large number of original variables to a smaller number of factors and to examine how the problem-solving process was experienced by the students. The Kaiser-Meyer-Olkin measure was within a very reasonable range; KMO = .80 (Norusis, 1988). Bartlett's test of sphericity also supported the use of a factor analytic approach (Bartlett's test = 845.9, $p < .00001$).

Results

The questionnaire data were analyzed with the SPSS program, utilizing principal axis factoring as the extraction method and varimax with Kaiser normalization as the rotation method. This method was used to determine how students experienced the key factors in their creative problem-solving processes. The exact number of factors was determined by means of Cattell's scree-test. The comprehensibility criteria were also used, and the number of factors was limited to four, since the meaning of the factors was then readily comprehensible (Duntzman, 1989). To determine the internal consistency of each factor, a Cronbach alpha coefficient, based on the average interitem correlation, was determined for each factor. The Cronbach alpha coefficients of the factors varied between 0.83 and 0.88. Each factor, therefore, measured one quality and, thus, a meaningful interpretation of the factors was possible. On the other hand, no far-reach-

ing generalizations were allowed regarding the structure or properties of the problem-solving processes. The factor analysis simply made it easier for us to describe how these 85 students experienced creative problem-solving processes during the CTEP.

On an aggregate level, these four factors explained 57.2% of the common variance, with eigenvalues of 6.19, 2.14, 1.42, and 1.13, and percentages of total variance of 32.57%, 11.26%, 7.46%, and 5.96%, respectively. The communality, 57.2%, indicated that four factors could be used satisfactorily as predictors for all 19 variables. Moreover, the extent to which each item played a role in the interpretation of the factors was high. The eigenvalues indicated that Factor 1 covered most of the variance, and the other factors each contributed about the same amount to the explanation of the variances.

Each of the four factors indicating the students' perspectives regarding problem-solving processes and variables (items) that described the highest loading on each factor are presented in Table 1. Three items also had loadings over 0.30 on other than their main factors, and these are commented upon below. The factors were labeled on the basis of researcher discussion on variables (items) loading on a factor. The means and standard deviations of each item are also presented in Table 1.

Factor 1, *success in problem-solving processes*, explained 32.5% of the total variance and included seven items. The first two items (F1-I1 and F1-I2) loading on this factor are connected to the problem-solving processes. Recognizing problems in one's surroundings (F1-I6) and restricting a problem (F1-I7) belong to the first phase of the process and are, therefore, a natural starting point for the problem-solving process. The creative atmosphere that is indicated in items F1-I5 and F1-I3 is necessary to establish a creative problem-solving process, but it is not sufficient to ensure that one can be launched. Another prerequisite for success would be knowledge about ideation techniques and ideation skills. These perspectives to problem-solving processes are indicated in items F1-I3 and F1-I4, which describe perspectives for ideation, but they do not tell how students suc-

ceeded in generating alternatives or about the quality of their ideation. On the other hand, these items also had high loadings (0.47 and 0.43) to the second factor dealing with the students' success in ideation.

Factor 2, *productive ideation*, consisting of six items, explained 11.3% of the variance indicating students' opinion about their ideation skills. Two items (F2-I1 and F2-I4) indicate the quality of the ideas. It is important that ideas generated during a creative process are original; otherwise one should label the process as routine. It is also important that the students learn to combine and develop others' ideas further. The key issue for success in creative processes is how the creative power of the group can be utilized in finding fresh ideas. The number of ideas (F2-I2, F2-I5) is also connected to their quality. It is known that in the beginning of an ideation session common, familiar ideas typically come to mind. Therefore, if there are many ideas in the group, at least some of them will be of high quality. It is important to use creativity (F2-I6) and to be both intuitive and systematic in turn (F2-I3) during the process of ideation. Item F2-I6 also had a high loading (0.40) on the fourth factor, which in this case dealt with positive attitude.

Factor 3, *collaborative support and evaluation*, consisting of four items, explained 7.5% of the variance. Items F3-I1 and F3-I4 indicate that students learned to express their feedback positively and constructively. The two remaining items (F3-I2, F3-I3) deal with positive attitudes when evaluating ideas.

The remaining two statements loaded on Factor 4, *positive attitude*, explained 6.0% of the variance. Item F4-I1 indicates that students behaved positively, and the other item (F4-I2) deals with a positive attitude as regards the creative process.

Means of the first two items loading on Factor F1 were 3.6 and 3.7. Thus, most students thought that they had learned about the nature of creative processes and how to work according to the principles of creative processes as well. This is what was expected, since these topics were emphasized during both the lecture and the

Table 1. Means and Standard Deviations and Varimax, with Kaiser Normalization Rotated Factor Loadings for Principal Axis Factoring, Calculated for the Items Measuring Primary School Student Teachers' Opinions About the Creative Process in the Project

	Mean	SD	Factor Loading
F1: Success in problem-solving processes			
Cronbach's alpha for the factor = 0.84			
F1-1: I learned to generate original ideas	3.37	84	.506
F1-2: I learned about the initial and creative processes	3.32	92	.851
F1-3: I learned to evaluate the value of the ideas generated to generate new alternatives	3.55	90	.595
F1-4: I learned to generate creative alternatives	3.07	90	.570
F1-5: I learned to generate a creative alternative	3.11	92	.563
F1-6: I learned to recognize problems around me	3.20	90	.140
F1-7: I learned to identify real and realistic problem	3.65	85	.115
F2: Productive ideation			
Cronbach's alpha for the factor = 0.84			
F2-1: I learned to generate original ideas	3.38	88	.769
F2-2: I learned to generate many alternatives	3.30	85	.767
F2-3: I learned to evaluate the value of the ideas generated	3.47	90	.695
F2-4: I learned to evaluate further ideas generated by other students	3.32	90	.578
F2-5: I learned to trust the good idea to have many ideas, at least some of them will be high quality ideas	3.51	85	.558
F2-6: I used my creativity	3.48	90	.187
F3: Collaborative support and evaluation			
Cronbach's alpha for the factor = 0.87			
F3-1: I learned to give positive feedback to other students' ideas	4.03	77	.883
F3-2: I learned to appreciate others' ideas	4.19	76	.845
F3-3: I learned to recognize advantages of the ideas of others	4.14	84	.877
F3-4: I learned to give constructive feedback to the ideas of other students	3.90	78	.646
F4: Positive attitude			
Cronbach's alpha for the factor = 0.85			
F4-1: I am positive about the creative processes	3.50	82	.530
F4-2: I took up positive attitude to creative processes	3.63	90	.726

workshops. Much time was also spent on understanding the meanings of ideation and the evaluation of ideas. Means of the items loading on the second factor indicate that, according to the self-evaluative data, the students had learned (at least reasonably well) to generate alternatives. Means of all items loading on the third factor indicate that the students had, in their own opinion, learned how to give positive and constructive feedback regarding other students' ideas. One may also note that much was discussed as regards how to give constructive feedback, which was also practiced during the project. Even the meaning and the value of such behavior during creative processes were discussed. The students were familiar, for example, with how positive feedback defines what is valuable in an idea presented by another student. Positive feedback also indicates where or from which direction possible solutions can be found. Moreover, positive peer feedback is important for the self-respect and confidence of other students.

Discussion

Based on the identified factors, the means and standard deviations of the self-evaluative

data on creative process skills, and the primary school student teachers' maps, it could be effectively argued that the OMPS method helps students understand the nature of creative processes and, particularly, that there are different phases involved in each of these processes. The mean (3.7) of item F1-I7 indicates that the students believed that they had learned to identify and restrict a problem. This is one of the most important phases in problem solving (Sapp, 1997). Factors 2 and 3 indicate that the students believed that they had succeeded in generating alternatives and, in particular, to evaluate and appreciate others' ideas. This means that the students felt that they had learned to give positive feedback regarding other students' ideas, to recognize the advantages of those ideas, and even to develop them further. It is obvious that a formal method in which each idea has to be backed up by the presentation of at least three reasons for its adoption is necessary for success. Such evaluation creates a nonjudgmental positive atmosphere for creativity, and it helps to behave positively as indicated in Factor 4.

On the other hand, the number of approaches ($M = 3.4$) and ideas ($M = 3.3$) generated during

the ideation phase was comparatively low. This was reflected by the students' opinion on the item I learned to generate original and new ideas. The mean of this item (3.4) was one of the lowest. Furthermore, the students felt that they did not learn enough about the generation of many original and new alternatives. Those skills are important when extremely new alternatives are wanted (Amabile, 1996). From the point of view of similar projects, it is important to observe that more efficient guidance in generating alternatives is needed. Students should be carefully introduced to techniques that can be used for generating numerous alternatives because the best way to get good ideas is to have plenty to choose from. It can be concluded that the outcomes of creative problem-solving activities depend on the creative processes as well as ideation techniques learned and applied (Smith, 1998).

The items measuring the students' success in the ideation and evaluation of ideas loaded on different factors. This result means that the students succeeded in separating those aspects when evaluating their problem solving. Both abilities (ideation and the evaluation of ideas) are essential for creative problem solving as well as the ability to segregate them. The ways in which the human mind works when creating new ideas can be argued. As de Bono (1970) emphasized, critical thinking is needed when

one is evaluating ideas and in the open creative thinking that is required to generate alternatives.

In summary, this case study indicates that creative problem-solving approaches may be efficiently used to improve teacher education. On the other hand, students must be encouraged to create many possible solutions to problems and then to select the best ones. Furthermore, students should receive a thorough introduction to creative problem solving in general (Williams & Williams, 1997). Such training could be beneficial because many students in our study became anxious when no formula existed or no direct guidance was given to their work. In addition, the recognition of facts connected to the background of the problem proved to be important in this study. Thus, it is essential for the creative process that students have relevant information available.

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The Effect of Problem-Solving Instruction on Children's Creativity and Self-efficacy in the Teaching of the Practical Arts Subject

Namyong Chung and Gyoung-sug Ro

Theoretical Framework

Practical arts is a subject that not only promotes learners' better understanding of work in their daily lives, but also enables them to find ways to solve work-related problems by fostering basic skills and attitudes necessary for performing the work (Ministry of Education, 1993). That is why the Ministry of Education in Korea (1993) identified the practical arts subject as a "practical living" subject, a "creative problem-solving subject," and an "integrated knowledge subject." Moreover, practical arts education in the aspect of its educational goal helps develop students' problem-solving and creative-thinking skills. In the methodological aspect, it also develops students' self-efficacy by helping them acquire daily living skills as well as the joy of work experience and a sense of accomplishment through experiential learning based on the work experience (Ministry of Education, 1993). That's why the Ministry of Education made the practical arts subject a required course for the elementary education system in Korea.

The teaching of practical arts as a subject should be focused on developing creativity and self-efficacy by the active employment of scientific thinking through the activity-centered decision-making process. Plus, the teaching of the practical arts subject must be conducted accord-

ing to the problem-solving model (Kwak, 1988; Seoul-Inchon Area Research Association of the Practical Arts Education, 1995; Research Association of the Practical Arts Education for All Korea National Universities of Education, 1997). However, most elementary school teachers in Korea have used the typical instruction method (lecture) to teach students the practical arts subject.

Choi (1997) suggested that practical arts education should be performed based on work experience activities by using problem-solving methods since the assumption of a model for the problem-solving method lies in the reflective thinking process; learners by themselves try to study creatively or reach conclusions comprehensively. And Kwak (1988) emphasized that the topics of practical arts education need to be taught by the problem-solving method while considering the necessity of problem-solving ability and creative thinking.

Na (1997) insisted that practical arts instruction should signify learner-centered instruction (i.e., learning by doing, using the various methods such as investigation, discussion, experiment, and work experience). While considering what students learned in previous instruction, then practical arts teachers could

Table 1. The Sexual Distribution of Subjects in the Study

Type	Male	Female	Total
Experimental	17	16	33
Control	16	17	33
Total	33	33	66

R ₁ (Problem-Solving Instruction Group)	O ₁	X ₁	O ₂
R ₂ (Problem-Solving Instruction Group)	O ₃	X ₂	O ₄

R1 : experimental group	X ₁ : problem-solving instruction	O ₁ , O ₃ : pre-test
R2 : comparative group	X ₂ : typical instruction	O ₂ , O ₄ : post-test

Figure 1. Quasi-experiment design.

Table 2. Creativity Measurement Factors and the Test Content

Factors	Time	Test Content
Fluency	3 min	As many imaginary words as possible to a given word should be written down within the time limit.
Flexibility	3 min	Many things which can be expressed in number in everyday life should be written down in number within the time limit.
Originality	4 min	By using the given vertical line, a student is required to draw a certain shape, and put down its name below it. The score is given only when the shape is unique. The drawing is graded according to the content of the shape.

Table 3. Comparison Between Problem-Solving Instruction and Typical Instruction

Problem-Solving Instruction		Typical Instruction	
Step1	Motivation	Introduction	Recalling the previous learning
Step2	Group objectives		
Step3	Confirmation of problems to solve	Development	Teacher-centered development of the current lesson
Step4	Problem-solving		
Step5	Test of solutions through application	Consolidation	Consolidating the current lesson
Step6	Evaluation of the solutions		

apply the content of the subject in the real situation by giving a sense of accomplishment as well as self-efficacy. Na added that in particular there should be priority in the student-centered problem-solving instruction so that creativity and self-efficacy could be developed.

But there exists a remarkable difference between the reality in educational fields and the researchers' insistence based on the result of the studies on problem-solving ability, creative thinking, and self-efficacy as shown in the above studies. In other words, creativity education as specified in the characteristics and goals of practical arts education has not been conducted properly, not to mention the lack of the establishment of a theoretical foundation for creativity education in the practical arts. However, Chung (1997) provided the theoretical foundation of creativity education in practical arts by analyzing the factors of creativity and their relation to the content of the practical arts subject and presenting the factors of the representative learning content for practical arts in each grade.

Hence, this study has two significant points: one is the examination of the effects on children's creativity and self-efficacy by apply-

ing problem-solving instruction in practical arts education, and the other is the implementation of the first study in Korea on problem-solving, creativity, and self-efficacy with the potential for further research.

The purpose of this study was to examine the effects on children's creativity and self-efficacy by applying problem-solving instruction in practical arts education and to show how this is reflected in the literature of problem-solving learning. The following delineations are the specific objectives used to achieve this purpose:

1. Identify the effects of problem-solving instruction on the development of children's creativity.
2. Identify the effects of problem-solving instruction on the children's self-efficacy.

Subjects for Study

For the subjects of this study, two out of seventh grade classes at H Elementary School in the city of Pohang, Kyungsanpook-do, Korea, studying practical arts as required in all Korean elementary schools were chosen as the experimental and comparative classes. The experimental group received problem-solving instruction for two hours a week, and the con-

Table 4. A Form for Problem-Solving Instruction

I. Unit and Theme
II. Analysis of the Actual State
III. Instructional Objectives
IV. Procedure of Teaching
1. Motivation
2. Expected Objectives of the Student Group
3. Expected Problems
4. Plan for Solving Each Problem
Problem 1: " method \neq data \neq summary
Problem 2, 3, 4, ... problem N
V. Application of Learning
VI. Reference and Teaching Aids
VII. Procedure of Assessment

Table 5. The Results of the Creativity Pre-Tests

Subarea	Class	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Frequency	Control	33	5.15	2.15	64	1.18
	Experimental	33	5.97	3.37		
Flexibility	Control	33	3.64	3.51	64	- 0.18
	Experimental	33	3.52	2.24		
Originality	Control	33	10.36	5.28	64	0.88
	Experimental	33	11.70	6.94		
Total (Creativity)	Control	33	19.75	8.03	64	0.92
	Experimental	33	21.18	9.38		

control group received typical instruction without emphasis on problem solving with all other factors being constant. The duration of the study was five weeks from May to June of 1999. The demographic information on the participating students is presented in Table 1.

Research Design

This study shows the progress of creativity and self-efficacy in the experimental and control groups after the experimental group received problem-solving instruction and the control group received typical instruction (i.e., without the problem-solving emphasis). Thus, the independent variables in this study were, as instructional methods, problem-solving instruction (for the experimental class) and typical instruction with no problem-solving component (for the control class). The dependent variables were the post-test scores of the creativity and self-efficacy tests. Figure 1, a diagram of the experimental design, examines the assumptions of the study.

Instrumentation

The existing creativity test instruments were not fit for the subjects and purpose of this study

since the instrument was made primarily for the target of upper grade students. Recently, for the third grade students, the Korea Creativity Research Institute (1998) developed the Creativity and Thinking Test with subareas for fluency, flexibility, and originality. The reliability of the creativity test was 0.93. The measurement factors and the test content are shown in Table 2.

The Self-Efficacy Test instrument was employed to measure the general level of self-efficacy on learning. In this study, the revised self-efficacy test from Sherer and Adams' (1983) questionnaire and Chung's (1987) questionnaire were employed (Cronbach alpha = 0.824).

Procedure

Homogeneity Test

In order to show the homogeneity between the experimental class and the control class, a pre-test was given to 246 students from seven third grade classes on Monday, April 26, 1999 (i.e., two weeks before the experiment). After the pre-test, two classes were chosen that showed little difference in the test, meaning

Table 6. The Results of the Self-Efficacy Pre-Tests

Type	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Control Experimental	33	80.52	17.61	64	1.27
	33	85.52	14.13		

Table 7. Comparison of the Pre-Test and Post-Test Results in the Creativity of the Control Class

Subarea	Test	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Frequency	Pre-test	33	5.15	2.15	32	6.84**
	Post-test	33	8.76	3.36		
Flexibility	Pre-test	33	3.64	3.51	32	2.49*
	Post-test	33	4.85	2.17		
Originality	Pre-test	33	10.36	5.28	32	-
	Post-test	33	10.36	5.28		
Total (Creativity)	Pre-test	33	19.75	8.03	32	6.94**
	Post-test	33	23.97	6.69		

* $p < .05$. ** $p < .01$.

Table 8. Comparison of the Pre-Test and Post-Test Results for Self-Efficacy in the Control Class

Type	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Pre-test	33	85.52	14.13	32	- 2.44*
Post-test	33	80.52	11.92		

* $p < .05$.

those two classes were not different in the aspect of students' creativity and self-efficacy. For the necessary time of the test, 30 minutes was allotted to the pre-test in considering the degree of students' attention and the range of the questionnaire. The post-test was administered in three weeks on July 5, 1999, after the experimental treatment (five weeks in total from May 10 to June 12, 1999). The test methodology and the time allotted for the post-test was equal to those of the pre-test.

Experiment Treatment

For the experimental treatment, the practical arts subject teaching plans with the problem-solving instruction component and the typical instruction method without such a component were approved by a preliminary examination of leading educators and elementary school teachers with expertise in the area. These two types of teaching plans are presented in Table 3.

Procedure of the Experiment

The teacher of the control class, who had almost equal educational experience in comparison with the teacher of the experimental class (researcher), clearly perceived the difference between problem-solving instruction and typical

instruction. The control class teacher was asked to conduct the instruction to the complete fulfillment of the constituent principle of each aspect of instruction.

The following control conditions were enforced to ensure the effects of this experiment:

1. Qualitative control: the instruction of the experimental class was implemented by the researcher
2. Quantitative control: two classes were equally conditioned in the progression of the instructional period and learning
3. Methodological control: the problem-solving instruction was implemented in the experimental class while the typical instruction was implemented in the control class
4. Content control: although the instructional style for the class was different, the content-instruction was equal.

Analysis of Data

This study aimed to investigate whether or not there was a meaningful difference in the degree of students' creativity and self-efficacy between an experimental group with problem-solving instruction and a comparative group

Table 9. Comparison of the Pre-Test and Post-Test Results in Creativity of the Experimental Class

Subarea	Test	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Frequency	Pre-test	33	5.97	2.15	32	6.08**
	Post-test	33	9.21	3.36		
Flexibility	Pre-test	33	3.64	3.52	32	5.03*
	Post-test	33	4.85	5.70		
Originality	Pre-test	33	10.36	11.70	32	7.84**
	Post-test	33	10.36	21.76		
Total (Creativity)	Pre-test	33	19.75	21.18	32	9.778**
	Post-test	33	23.97	36.67		

* $p < .05$. ** $p < .01$.

Table 10. Comparison of the Pre-Test and Post-Test Results in the Self-Efficacy of the Experimental Class

Type	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Pre-test	33	80.52	17.61	32	1.67
Post-test	33	83.79	17.25		

with traditional instruction. The collected data were analyzed by SPSS WIN, 7.5 version. Frequency, percentage, average, and standard deviation were employed, and the *t* test was also used to make a comparative analysis between the results from the experimental class and the control class.

Results

Homogeneity Between the Experimental Class and the Control Class

With the purpose of estimating the homogeneity between the experimental class and the control class, pre-tests of creativity and self-efficacy were conducted. The results of the pre-test presented in Table 5 showed no meaningful statistical difference between the two classes, and likewise in creativity subareas including fluency, flexibility, and originality. So, in the aspect of creativity, the experimental class and the control class should be regarded as identical.

The pre-test results for students' self-efficacy in the experimental and the control class indicated, as in Table 6, no meaningful difference. Thus, the two classes were equal in the aspect of self-efficacy.

Comparison of the Pre-Test and the Post-Test of the Control Group

The pre-test and post-test comparison results of students' creativity in the control class are shown in Table 7. There was a significant

difference between the pre-test result and the post-test result in creativity, and likewise in the tests of creativity subareas including fluency and flexibility. However, the pre-test and the post-test in originality as a subarea of creativity showed no significant statistical difference.

The pre-test and post-test for self-efficacy in the control group showed a statistically significant difference as shown in Table 8, but the score for the control class was found to be lower than before the experiment.

Comparison of the Pre-Test and Post-Test in the Experimental Group

The pre-test and post-test results in students' creativity indicated that there was a statistically significant difference between the pre-test and the post-test results since the creativity test score was increased in accordance with the experimental treatment with problem-solving instruction as indicated in Table 9. Moreover, there were significant differences in the creativity subareas, which included fluency, flexibility, and originality. This confirmed that the problem-solving instruction could enhance the subareas of creativity.

The pre-test and post-test results for self-efficacy showed no statistically significant difference as shown in Table 10, but there was a minor increase in the average of the test scores.

Table 11. Comparison of the Post-Test Results in Creativity in the Control Class and the Experimental Class

Subarea	Test	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Frequency	Pre-test	33	8.76	3.36	64	0.46
	Post-test	33	9.21	4.62		
Flexibility	Pre-test	33	4.85	2.17	64	1.27
	Post-test	33	5.70	3.18		
Originality	Pre-test	33	10.36	5.28	64	6.31**
	Post-test	33	21.76	8.92		
Total (Creativity)	Pre-test	33	23.97	6.69	64	5.04**
	Post-test	33	36.67	12.83		

** $p < .01$.

Table 12. Comparison of the Post-Test Results for Students' Self-Efficacy in the Control Class and the Experimental Class

Type	<i>n</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> value
Pre-test	33	80.06	11.92	64	1.02
Post-test	33	83.79	17.25		

Comparison Between the Post-Test Results in the Control Class and the Experimental Class

The result of the post-test for students' creativity showed that there was a statistically significant difference between the control class and the experimental class as indicated in Table 11. In the creativity subareas, the aspects of fluency and flexibility showed no statistical significant difference between the two classes, but in the aspect of originality, a significant difference between the two groups was demonstrated. For this reason, the problem-solving instruction could be said to have more impact on the advancement of creativity than in the case of traditional instruction.

Although the post-tests for self-efficacy in the control group and the experimental group showed no statistically significant difference as shown in Table 12, the comparison of average scores on the post-tests for students' self-efficacy indicated higher scores in the experimental class than in the control class.

Conclusions and Discussion

The findings reflect several significant differences between the typical instruction group and the group with the problem-solving component. From the findings, the following conclusions can be drawn:

1. The problem-solving instruction showed a marked effect on originality, whereas the

other creativity subareas, including fluency and flexibility, showed just a slightly higher average not large enough to be statistically significant. The reason for not showing a statistically significant difference in fluency and flexibility might be the short period of the experiment's duration. Therefore, using problem-solving instruction in the long term can also have an effect on other subareas of creativity.

2. The problem-solving instruction within the context of practical arts class showed no statistically significant difference in students' self-efficacy, but the experimental class got a higher average score on the post-test. This might also be caused by the short period of the experiment's duration.
3. In the traditional instruction without the problem-solving component, students' self-efficacy was significantly lowered after the instruction period. This result could have been caused by (a) the short-term experiment or (b) the control group teacher who used a bad teaching skill. However, this result still indicates that typical instruction can be an obstacle in the development of children's self-efficacy.

All the details above indicate that the problem-solving instruction for elementary school children is related to the teaching-learning process in promoting children's creativity.

However, previous research on the effect of problem-solving instruction has suggested that it is difficult to draw a general conclusion that one process of instruction is always more effective than others. This is why one kind of teaching-learning process does not necessarily or consistently work better than others. Moreover, change in self-efficacy during the short term is hard to assess. Thus, only after the steady use of problem-solving instruction can a positive change in children's self-efficacy likely be noted.

Recommendations

The following recommendations are based on the findings and conclusions of this study:

1. Research on various methods to develop creativity and the development of an instructional model and learning materials are needed.
2. The positive effect of problem-solving instruction can be expected in subjects other than practical arts if problem-solving instruction is employed. Therefore, the experimental study of problem-solving instruction compared with traditional non-problem-solving instruction is suggested.
3. Long-term study of the promotion of creativity and development of curricula connecting elementary and secondary education is recommended.
4. This study has significance in the point that there was an attempt to promote creativity by using problem-solving instruction in the teaching of practical arts and that this study can be utilized in other subjects as well.

The theories and research with positive results for children are not supposed to be directly used without any pre-examination or regard of the students (subjects). Instead, there should be an understanding of children's abilities and verification of the effects of theories and methods suitable for children by carefully examining them prior to implementation.

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Energy Technology: A Cross-Curricular Approach in Japan

Sadato Yamazaki, Cyril King, Mika Shinde, Osamu Ohiwa, and Sohichiro Hirai

This article briefly describes a curriculum study that had two main purposes. The first purpose was to develop and reflect upon a new energy technology curriculum at the lower secondary school level using an action research method. The second purpose was to determine the effect of collaborative activities, with the families of the pupils enrolled in the curriculum, as a means to help develop pupils' cross-curricular competence.

Yamazaki (1999a, 1999b), Yamazaki and King (1998), and Yamazaki, King, and Preitz (2000) proposed conceptual frameworks for curricular themes and activities for technology education based on a whole curriculum concept. The authors gave serious consideration to both accountability and collaboration between the school, family, and community. In order to emphasize the interdisciplinary relationship between each technological activity and other subject areas, the authors introduced four intra cross-curricular technology themes as a general education experience from kindergarten to upper secondary school: (a) developing resources, processing materials, and making products; (b) converting, transmitting, and conserving forms of energy; (c) processing, transmitting, and controlling information; and (d) developing and conserving biological resources.

In addition, it was recognized that technolo-

gy instruction involves the following creative, problem-solving processes: identifying technological problems to be resolved; planning, designing, and communicating; manufacturing; and reflecting on technology and assessing the impact on the environment and society.

Ohnuma, Takahashi, Kasahara, and Yamazaki (1997) and Yamazaki et al. (2000) identified, through action research, the importance of three inter cross-curricular themes throughout formal, nonformal, and informal education: environmental study; foods, human health, and life skills; and mutual understanding between communities as well as international societies.

The Japanese Society of Technology Education (JSTE, 1999) also proposed two frameworks for providing opportunities in technology education as a general education for all, from kindergarten through upper secondary school. Four technology related curricular themes were identified as being closely associated with technology education: working with materials and processing technology; energy conversion technology; information, systems, and control technology; and bio-related technology.

We propose technological processing as a fifth curricular theme closely associated with technology education (see Figure 1).

Figure 1. Systems approach of technological problem solving in action

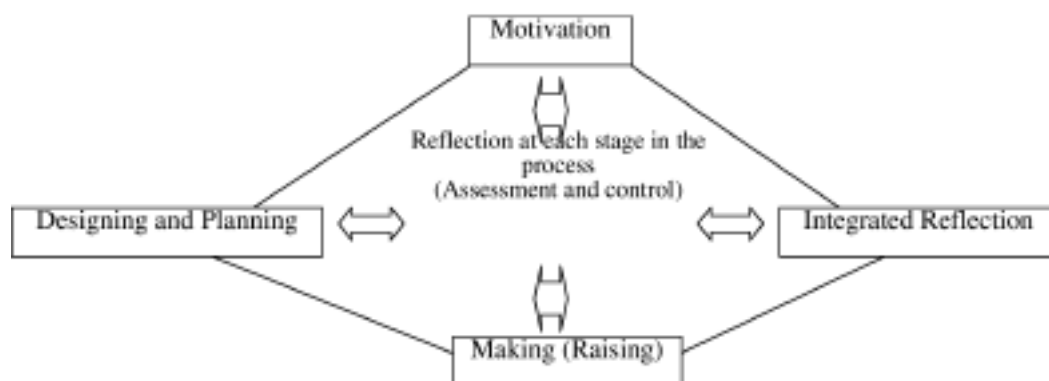


Table 1. Curriculum and Modules

First term (total of 6 class hours in grade 8)	
Module 1	Is the plug receptacle (socket) in your home really safe?
Module 2	Let's make an electrical extension lead.
Module 3	Let's develop an instruction sheet on how to use home electricity safely.
Second term (total of 18 class hours in grade 9)	
Module 4	Let's study electrical energy utilization in an earthquake disaster.
Module 5	Let's investigate wind, thermoelectric and atomic power stations in Joetsu district.
Module 6	Let's generate electricity by a hand-powered generator.
Module 7	Let's make a germanium radio without electric power.
Module 8	Let's make a radio with an emergency light generated by hand power.
Module 9	Let's consider how to use the radio to provide against contingencies.

Table 2. The Results of ANOVA Analysis in Each Comparison Between Pre and Post Self- Assessments

[1] Variables of capabilities about inter cross-curricular themes		
(3)	Safe management of natural resources and environmental preservation in home life, as a pupil makes all the members of own family understand and cooperate	A X C: 7.88** B: 2.85+
(4)	Using electrical appliances in a safety conscious way	A: 4.22*
(5)	Explanation about prevention of electrical disasters and safety regulations	C: 11.93**
(6)	Using electrical appliances with consciousness about environmental preservation	A: 6.16* B: 4.16*
(7)	Explanation about relationship between electricity and natural resources or environmental preservation	C: 4.19*
[2] Variables of capability of electricity in technology education		
(2)	Putting knowledge and skills, which the pupil studies in technology classroom, to practical use	C: 4.24*
(8)	Interest in assembling and repairing electrical appliances	C: 4.24*
(9)	Handling and good management of an electrical extension lead	C: 39.33**
(10)	Interest in the study of electricity	A X B: 4.79*
(11)	Understanding that it is dangerous to use electrical appliances inappropriately	A X C: 4.57*
[3] Variables of capability of portfolio study		
(12)	Bringing and using portfolio on electricity study for homework	Ns
(13)	Putting portfolio on electricity study to practical use	Ns
(14)	Writing and making portfolio to review in class	A: 8.77** B: 6.48**
(15)	Preparing study using portfolio	B X C: 4.02*
[4] Variables of capability of collaborative study with own family		
(1)	Collaborative study on portfolio in technology education with own family	A X B X C: 2.65 +
(16)	Review, with comments from own family about portfolio	C: 8.55**
(17)	Communication skills to make own family engage in the collaborative study	C: 5.59*

+ $p < .10$. * $p < .05$. ** $p < .01$.

Note 1:

Factor A: a comparison between a class of self-study and a class of collaborative study with pupil's family; Factor B: a comparison between higher, middle, and lower levels of achievements in technology education; Factor C: a comparison between pre and post self-assessments.

Note 2:

The number of pupils in the class of self-study was 38 (male 18, Female 20). The number of pupils in the class of collaborative study with the family was 38 (male 19, female 19).

Action Research

The Niigata and Ibaraki Prefectural Technology and Homemaking Teacher Research Associations, which are members of the All Japan Technology and Homemaking Teacher Research Association, cooperated in this action

research. Teachers of the Naoetsu and Chiyokawa Public Lower Secondary Schools also collaborated in this study from 1996 to 1999. Naoetsu Lower Secondary School is located on the west coast of Honshu, the Sea of Japan side of the island. Chiyokawa Lower Secondary

School is located in Ibaraki prefecture next to Tokyo's metropolitan district. Participants were Grade 8 and 9 pupils who were enrolled in a compulsory course in technology and home-making. The analysis of data was based on two Grade 8 classes in Naoetsu Lower Secondary School.

Curriculum and Modules

The curriculum and modules used within this study are shown in Table 1. Since the schools in this study were not authorized by the Ministry of Education Science, Sports and Culture of the Government of Japan as curricular experimental schools, the statutory course of study for lower secondary schools issued in 1989 (Ministry of Education Science, Sports and Culture, 1989) was adhered to in this study. Accordingly, we developed a school-based curriculum for use in the two schools.

As part of the study, we developed curriculum content links between the lower secondary school compulsory subject areas of technology and homemaking, and science. The technology and homemaking subject area requires pupils to study woodworking and home living at Grade 7, and electricity, food, and another three topics at Grades 8 to 9.

Another key aspect of the study was the production of portfolios of study by the pupils.

We proposed that the production and use of these portfolios would help pupils develop competence in both technological creative processes and collaborative study.

Quantitative Approach

This article reports on the quantitative and qualitative studies undertaken in Term 1. In order to investigate the effect of collaborative study with the pupils' families in the development of the curriculum, a three (A x B x C) factorial design research was carried out as part of the main research from October to November 1998 (see Table 2).

Factor A compared a self-study group and a collaborative study group with the pupils' families. Factor B compared higher, middle, and lower levels of pupil achievement in technology education. Factor C compared pre and post self-assessments. Pupils were pre and post self-assessed by means of a 6-point scale in each term.

Qualitative Approach

Pupils' descriptions and comments in their portfolios of study, and interviews with some pupils, were used as assessment devices. Participants were also observed in order to collect ethnographic data in real classroom situations. Pupils also had the opportunity to give their written evaluations within two weeks of finishing Term 1.

Figure 2. The average of self-assessment as compared with self-study and collaborative groups

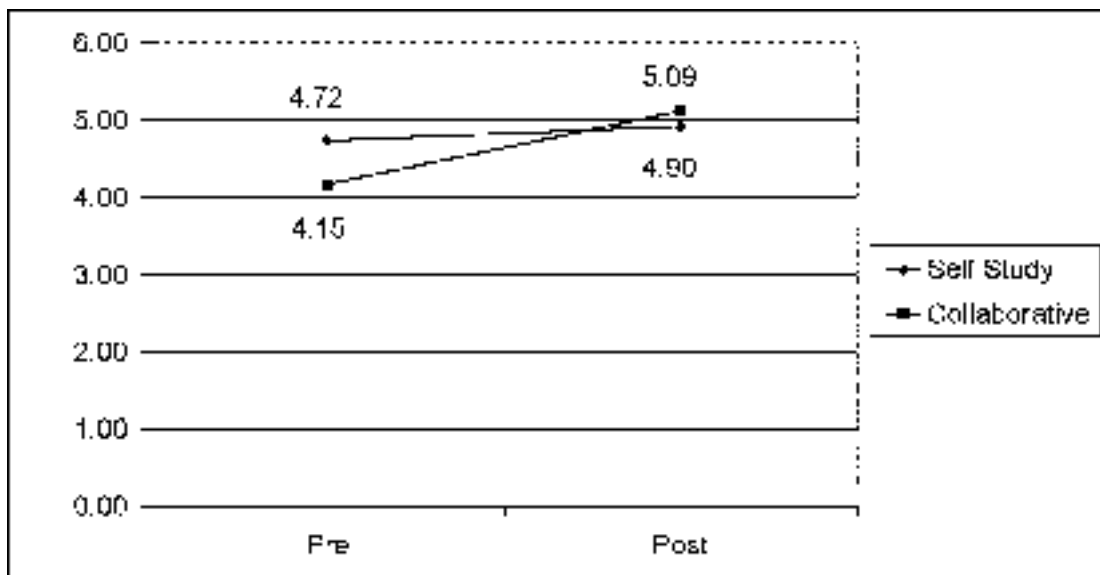


Table 3. Number of Pupils Who Commented in the Delayed Assessment on Electricity Study and How They Practiced in Real Life

Item of Pupils' Pre-assessment	Family Study (N=38) Number of Pupils	Collaborative Study (N=38) Number of Pupils
(1) Nothing	21	9
(2) About electric power saving	5	9
(3) Connected how to use electrical load	4	6
(4) Do not act dangerously when using electricity	0	1
(5) Other	0	3
(6) Unknown	4	1
(7) No description	5	5

Table 4. Data of Comparison Between Pre and Post Self-Assessment in Case of Pupil W (Female)

Item	Pre	Post
(1) Understanding that it is dangerous to use electrical appliances inappropriately	1	6
(2) Using electrical appliances in a safety-conscious way	1	5
(6) Using electrical appliances with consciousness of environmental preservation	1	3

The Curriculum Approach's Effects

Statistical Results

Because it is impossible to control experimental circumstances in a general, real classroom study, it is important to interpret and apply the data on pupils' pre assessment. The technology teacher Ohiwa, one of the authors, recognized that there were not large differences in his pupils' achievement, capability, and motivation. However, the authors, including the teacher, considered that there were some different ethnographical contexts between each class. Identifying the sociocultural context of the classroom is important in undertaking action research.

The results of the ANOVA analysis between pre and post self-assessments is shown in Table 2. The data for Item 3 shows that the interaction between A (self vs. collaborative study) x C (pre vs. post) was significant. The main effect of Factor B (a degree of achievement) has significant tendency. The simple effect of Factor A was significant. The simple effect of Factor C, with a degree of error at each level, has significant tendency. Therefore, the data highlights the effect of collaborative study involving the family.

The average of self-assessment as compared with self-study and collaborative groups in Item 3 is shown in Figure 2.

Portfolios, Cases, and Interviews

Item 1 in Table 3 shows a significance between self and collaborative study with the family. In the class where pupils undertook the collaborative study with their families, nine pupils described electric power saving. It is clear that the pupils also performed as a contact person and link between the class and family.

Case Studies

A comparison between pre and post self-assessments in the case of Pupil W (female) is shown in Table 4. She gained the highest scores in Item 11 in the post self-assessment though lowest in the pre self-assessment. In addition, she produced a very good portfolio entitled "Are My Home's Plug Receptacles Really Safe?" As part of her portfolio, she made an instruction manual, in the form of a cartoon comic strip, on how to safely use and manage electricity safely.

Data for Pupil F (female) are shown in Table 5. In her portfolio, she studied how handicapped or aged people safely use electrical appliances. In addition, she paid attention to how to use electricity, taking account of environmental preservation and prevention of disasters. In the interview with her, she answered that her father was very helpful in giving her useful information.

Table 6 shows a third case study involving Pupil W (female). The topic in her portfolio

Table 5. Data of Comparison Between Pre and Post Self-Assessment in Case of "Pupil F" (Female)

Competency	Pre	Post
(9) Handling and managing an electrical extension cord appropriately	2	6
(6) Using electrical appliances with consciousness of environmental preservation	4	6
(11) Bringing and using portfolio on electricity study for homework	4	6
(5) Explanation about prevention of electrical disasters and safety regulations	3	5

Table 6. Data of Comparison Between Pre and Post Self Assessment in Case of Pupil W (Female)

Competency	Pre	Post
(10) Using electrical appliances with consciousness of environmental preservation	2	5
(3) Safe management of natural resources and environmental preservation in home life, as a pupil makes all the members of own family understand and cooperate	4	6
(5) Explanation about prevention of electrical disasters and safety regulations	1	3

was how to economize in the use of electric power. She investigated the methods of saving in the use of electric power for household lights, a refrigerator, televisions, a video player, an air conditioner and its remote controller, and a personal computer. She described the dangers of putting too much load on one electric outlet. She also noted how to use instruction manuals on electrical appliances and how they should be electrically grounded. In her interview, she was pleased that she undertook a beneficial collaborative study with her father in her homework because he was employed by an electricity company. The results show that both intra and inter cross-curricular approaches, together with collaborative study with the family, are very effective in developing trans-disciplinary competence.

What We Believe the Study Indicates

It is clear that the indigenous and school-based cross-curricular approaches in energy technology developed in this study are effective.

This study has shown some evidence of the educational benefits of pupils' collaborative

study with their families in energy technology.

The development of a portfolio is a very efficient study method in helping pupils develop cross-curricular competence.

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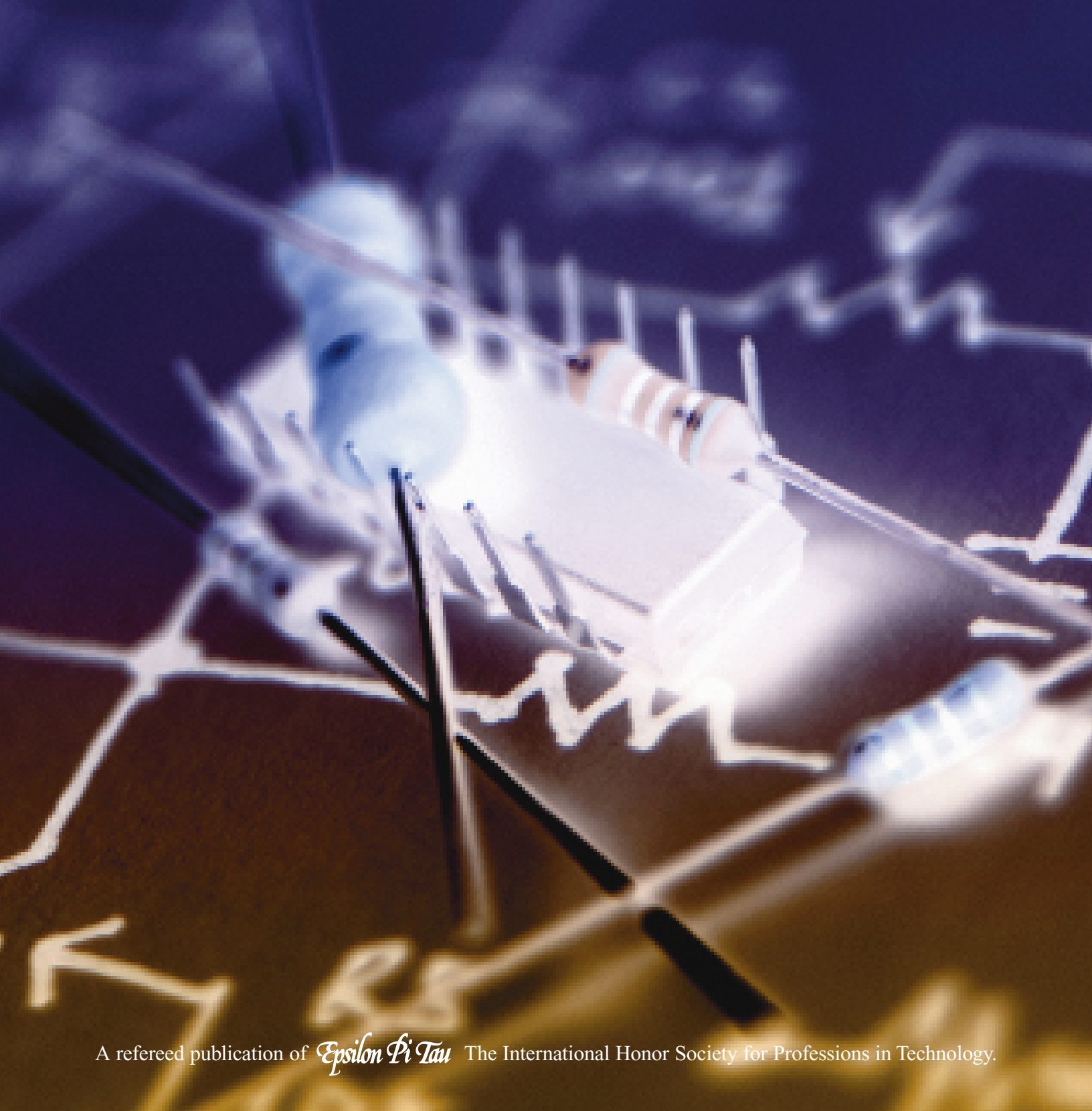
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Promoting Excellence in Preparation and Excellence in Practice

Volume XXX, 2004
No. 3 Summer 2004

The Journal of Technology Studies



A refereed publication of *Epsilon Pi Tau* The International Honor Society for Professions in Technology.

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The Journal of Technology Studies (JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc., a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0305. Use this address or jots@bgnet.bgsu.edu for subscription matters or purchases.

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The journal is currently indexed in: Current Index to Journals of Education (USA); International Bibliography of the Social Sciences (IBSS) (UK); and the International Vocational Education and Training and Research Database at <http://www.ncver.edu.au> (Australia).

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Printed in the United States of America by Kennedy Printing Company, Findlay, Ohio.

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Articles

Designing Technology Education at the Junior High School Level: Propositions from the French School Curriculum

By Lebeaume Joël

Joël Lebeaume is a professor at the École Normale Supérieure of Cachan. His research is focused on technology education from a didactic point of view at the Unity of Research in Scientific and Technology Education (UMR STEF ENS Cachan INRP). He has been a member of the "Technology" working group with the Ministry of Education and has participated in the examination and review of new programs in the area of technology education.

In France, technology is a compulsory school discipline at the junior high school level (ages 11-15). Technology studies were initiated at the beginning of the 1960s when school attendance until the age of 16 became mandatory and when it was decided to delay vocational training because of the irreversible drive towards technical modernity, a tremendous cultural and social upheaval, and a dire shortage of technicians in France. Designing and implementing this new discipline, however, could not happen spontaneously; it required the appropriate tools, in addition to ideas, in order to develop and coalesce the various suggestions, identify likely consequences, and propose a coherent structure. Across the world, technology education systems vary depending upon political, economic, and technical contexts, etc. (de Vries, 1994; Foster, 1997; Zuga, 1997). These differences are also tied to the historical forms of this subject matter, such as industrial arts, design, and arts and crafts, and the relationships held with other disciplines in the educational curriculum. Moreover, they depend upon the philosophical precepts inherent in the definition of the discipline, that is, content-oriented vs. student-oriented.

Within the French context, research on the history of this discipline (with a focus on manual work) provides insight into the fundamental issues of its place in the compulsory general school curriculum. Such research has provided the basis for suggesting a number of tools for

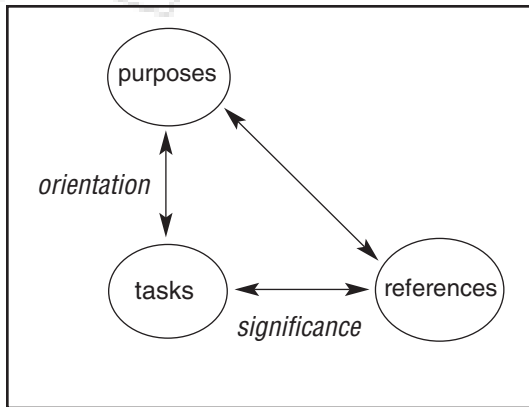
identifying relevant proposals from recent technology education programs (1996-1998).

This historical inquiry examines two main periods of school organization in France. The first concerns the period 1880 to 1960, during which primary schooling was opened up to the entire population. The second is the period 1960 to 2000, when the school became an educational system and when the junior high school progressively filled the role of middle school. During both periods, the technical world was represented first by means of manual work and then with technological instruction. This historical approach serves to develop a didactic frame of reference specifically regarding prescribed course content and curriculum organization (Lebeaume, 1996, 2000). The two aspects are indeed similar due to the context of compulsory teaching within the general education system.

Manual Work at the Primary School Level

For the past 100 years or so, manual work has been prescribed for boys and girls at the primary school level. The name of this discipline has been modified over the years: manual and experimental work, manual activities, manual educational activities, manual work, handicrafts, etc. These changes are the consequence not only of evolution in the pedagogical conceptions of children and pupils and of their learning, but also in the social roles of men and women. In order to identify the various forms of this discipline, it becomes necessary to characterize the predominant prototypical situations encountered in teaching-learning. A prototypical situation is characterized by the tasks, their significance, and their orientation: What exactly are the pupils doing? And why are they doing it? How do these tasks refer to actual practices? Figure 1 illustrates this coherence in the reciprocal relationships between the three components of this discipline: purposes, references, and tasks.

Figure 1. Representation of prototypical teaching-learning situations: Method.



The diagram in Figure 1 depicts the coherent structure present in each form of the discipline and represents a method, which is to be defined as the special methodology of the discipline. It is necessary to distinguish between the pedagogical and didactic meanings of the methods observed. This distinction does not pertain to the relationships between purposes and means, as do the active methods (pedagogical meaning). According to the didactics perspective, the term *method* draws attention to subject content. It indicates the special methodology behind a school subject, with its features and its specific knowledge. It has been used in the past for music learning, for example, to distinguish between the marked method and the numbered method.

The various forms of manual work at the primary school level are thus: the technical elements method (e.g., series of sewing stitches for girls, or technical elements of woodwork or metalwork), the everyday items method (creation of objects, such as pillowcases, boxes,

or tablemats), the geometrical elements method (drawing shapes, folding paper), the amusing things method (toys, dolls, etc.), the logical elements method (graphical representation of threads in braiding, weaving, etc.), and the technical projects method (process of producing technical objects). Each of these methods is represented in the chronological diagram in Figure 2.

The main differences between these historical forms of manual work depend on both the tasks and their references. Some tasks refer to domestic practices, whereas others relate more to workshop activities or industrial jobs and still others to entertainment practices. The significance ascribed to the tasks influences them via systematic exercises or practical activities. Task objectives are also contrasted when it comes to learning technical matters, scientific or mathematical knowledge, understanding the psychological development of children, and discovering the technical world. Without necessarily being aimed at pre-professional training, these purposes were all quite different. Coherence has thus been defined in each of these prototypical situations, as identified respectively by the corresponding methods.

Technology Education at the Middle School Level

The history of technology education since the 1960s also reveals the distinct methods employed at the junior high school level. In the past, it had been organized according to a succession of methods, each featuring special attributes (see Figure 3).

Figure 2. Successive methods throughout the history of manual work in primary schools.

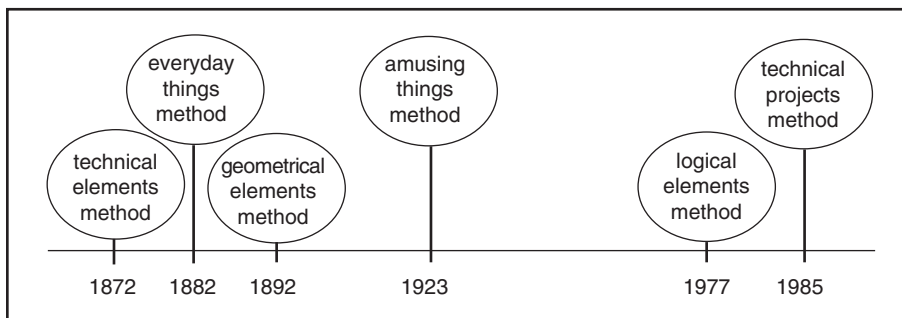
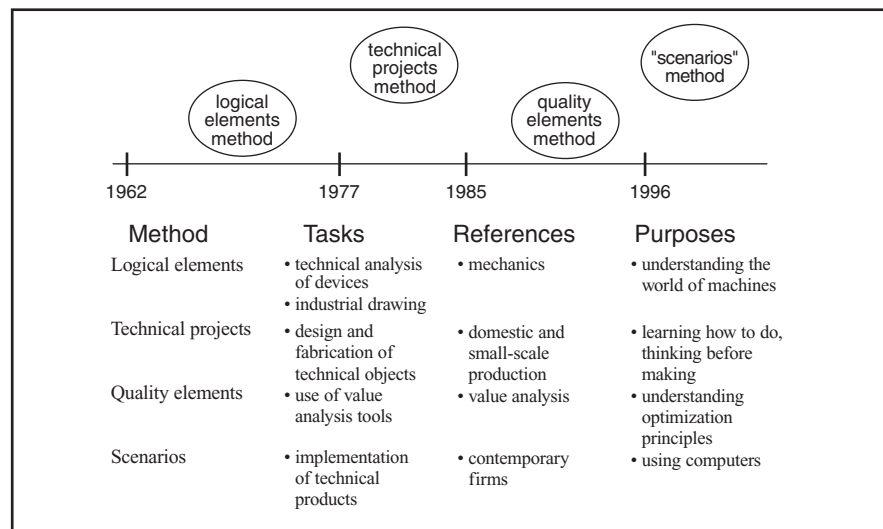


Figure 3. Methods used in the history of technology education for middle schools.



According to these various forms, technology education may be defined as a component of general education without the goal of being or becoming vocational training. Rather, it is intended as a discovery or initiation to technical practices in order to better cope with and act within the technical environment. Technology education has also been constituted as a requisite school discipline for identifying future jobs and professions.

The successive forms of the discipline at both the primary and middle school levels reveal an alternation in the methods adopted. Two types of methods can be distinguished: syllabic methods and global methods. The first are defined merely by elementary efforts or notions along with the pertinent scientific references, whereas the second are defined by the production of basic objects adapted for the students' comprehension. The first are devoid of any technical significance, whereas the second imply a translation for youngsters of real-world practices as a means of proposing technical educational experiences. This alternation is a sign of the instability of technology education in schools, which often tends to become a series of lessons with a pencil and paper but without authenticity or connection to real-world technical practices.

Main Theoretical Issues

The historical analysis of this school discipline raises three main issues with respect to designing technology education within a compulsory general educational context:

1. How to handle the interactions between knowing and doing in order to design an academic discipline based on reasoning and action.
2. How to harmonize the diversity of technical practices in designing a general school discipline.
3. How to maintain relationships with current social and technical practices so as to provide pupils with genuine interpretations of the technical world they will be required to understand.

These three main issues are fundamental to the design of an elementary, progressive, and general approach towards a whole range of situations combined into a single school discipline under the generic label *technology education*.

Designing the Foundations of Technology Education

The diagram in Figure 1 serves as a base to query the foundations of technology education. Which tasks are appropriate? For which purposes? Which references apply to the set of tasks? The choice regarding references and purposes depends on educational policies aimed at training young people as individuals, citizens, and future members of the workforce. The choice of industrial practices as references is directly linked to the conception of the future from a social and economic standpoint. Is it important to initiate entrepreneurship (Raat, de Vries, & Mottier, 1995), to develop a critical point of view (Deforge, 1993; Petrina, 2000), to promote scien-

Table 1. Comparison of T/M/S Content Standards

Area	# of Stds	Second Level (9-12) Statements	Grade Bands	Date Issued	Web Site
TECH	17 cognitive 3 process	51 cognitive 15 process	K-2 3-5 6-8 9-12	2000	www.iteawww.org
MATH	5 cognitive 5 process	71 cognitive 18 process	PreK-2 3-5 6-8 9-12	1989/2000	www.nctm.org
SCIENCE	7 cognitive 1 process	27 cognitive 2 process	K-4 5-8 9-12	1995	www.nas.org

tific and technical progress, to maintain the technical heritage, to generate new individual or collective skills, etc. Within the French context, history has demonstrated the various choices made over the past 30 years: to enhance the condition of manual workers; to generate enthusiasm for technical jobs; to fulfill the broad-based needs of technicians, marketing professionals, and engineers; to inform customers; etc. The question of why technology education should be included within the compulsory school curriculum is linked to the question regarding references that entails contemporary firms, mass production, workshop activities, etc., as well as to that regarding the choice of fields of technical practice such as mechanics, electronics, economics, and automation (Martinand, 1995).

In relation to the previous choices, the fundamental decision about curriculum would thereby constitute the main type of approach. Would this be a production approach; or an investigation approach of processes and devices; or an analytical approach of quality, objects, and products; or another approach altogether? Depending on the decisions concerning the three method components, a different technology education comes to the fore with a distinct set of contents. The discipline could consist of an experimental technology education, a practical technology education, a design-process technology education, a problem-solving technology education, a creative technology education, and so forth.

In France, the preferred approach has always been to rely upon project-building adapted to the pupils' ages. This decision, however, requires a conceptual framework in order to describe the nature of the school tasks

assigned. In technology education, tasks must integrate material of a technical nature, which has been defined from three components (Combarrous, 1984): objects, technical thinking, and specialized roles. Put otherwise, a technical task arises when pupils are confronted with objects (machines, materials, documents, etc.); when they are asked to design, produce, or, more simply, act or carry out as efficiently as possible; and when they play a technical role such as engineer, technician, or technical agent in a context of teamwork. Nevertheless, this project development approach merely involves a few genuine encounters with the technical world without the intention of training project managers or specialized agents.

These encounters with the technical world via a project development approach then serve as a means for interpreting real technical processes and products. School projects enable not only the generating of vital concepts for examining technical reality, such as quality, value, cost, market, organization, and technical standards, but also learning some machine and computer operating skills.

While concrete technical achievements lie at the core of technology education, the use of computers is very closely related therein. Learning how to use computers thoroughly is essential for future generations. Technology education has the obligation of teaching these multiple computer uses (word processing, spreadsheet applications, database management, computer-assisted drawing and manufacturing, communication applications, etc.). One aspect of these programs is centered directly upon the

acquisition of such knowledge. This aspect does not fall into the realm of information sciences but rather of information technology, as a result of the technological point of view inherent in this systematic learning approach. However, information technology does not span the domain of the unconscious use of computers. To handle these machines better, practical familiarization does not consist solely of hands-on use but includes reflexive practice as well. Learning is organized by virtue of progressive exercises aimed at understanding how to use computers and how to open, enter, select, locate, save, store, and retrieve files. These capacities must be taught so as to remain with the pupil for future activities and to assist in day-to-day life. Pupils need to know about systems and principles of data processing and assimilate these processes in order to identify the advantages and limitations of data-handling programs or choose from among a set of programs. They also have to build an effective model for dealing with computer-related tasks.

Designing the Organization of Technology Education

Designing the organization of technology education within a general educational context raises two major and interrelated issues: how the program is to be defined within the framework of elementary learning and how its progressive evolution is to be organized. Focus then turns to the schedule of technology education courses during the four-year junior high school curriculum.

Given that school disciplines are defined simply by a sequence of knowledge acquisition, it is customary to divide the contents into a number of small chunks and then teach them one after the other. Mathematics or grammar lessons, for example, are typically organized around this principle from the simplest to the most complex. In contrast, for technology education (and for that matter for sports and artistic education as well), specific content components cannot be separated into smaller chunks. In the past, this tendency to define technology education as a cumulative discipline distorted its foundations and the school subject got directed towards applied sciences or geometry.

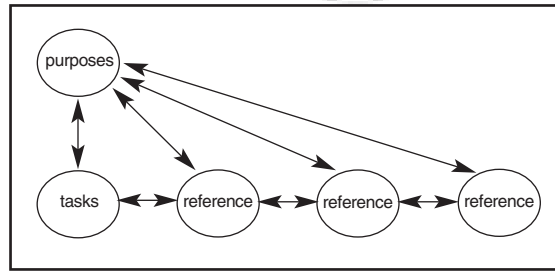
In order to maintain its foundations, technology education must generate prototypical teaching-learning situations from tasks featuring a real technical nature. Defining an elementary school discipline implies choosing technical experiences adapted to the pupils (i.e., enabling them to live a series of adventures shaped by objects, efficiency, and roles). It is also necessary, however, to organize these experiences within a coherent sequence throughout the schooling period.

The history of technology education reveals several principles for determining the progression of the curriculum. The first one consists of repeating the same process in different technical experiences throughout the junior high school program. This principle is at odds with the purpose of technology education by virtue of the tendency of such training to produce project managers. The second principle consists of introducing these school experiences gradually with more open-ended tasks: resources are increasingly scarce, technical projects are increasingly complex, and constraints are increasingly present. This principle corresponds with the definition of technology education as both a school discipline that contributes to developing problem-solving skills and a pedagogical means for nurturing the pupils' psychological skills. The third principle consists of defining just one generic technical area and then progressively introducing new and broader tasks. In the past, the areas of woodworking or metalworking and the realm of mechanical practices constituted these generic references, which provided an overview of the entire array of technical practices. This choice, however, does not comply with the purpose of unspecialized education because of its tendency of becoming more of a vocational training. The fourth principle consists of varying the references from more familiar to more unknown domains, for example, from the home to firms or from domestic practices to industrial practices. This principle is typically applied at the nursery school and primary school levels, where discovery of the world initially proceeds from commonplace tools and familiar objects. The fifth principle consists of proposing different technical experiences encompassing a wide diversity of

social and technical references. As an example, the program prescribes technological activities in sewing, cooking, building, electronics, and mechanical assembly. Comparison between these contrasted experiences then enables identifying the consistency of the technical process or tasks along with their technical features. This principle, however, has more to do with planning than with a progressive pace to the instruction. Keep in mind that progressiveness pertains not only to the temporal organization but also to the way in which pupils progress with their learning.

The choice of which principle to employ in setting up a general, elementary, and progressive technology education depends on the purposes inherent in the school discipline. Within the French context, the principle of elementary teaching entails defining project-based accomplishments, whereas the principle of progressiveness implies distinguishing tasks according to the three junior high school degrees. During the first degree, the principle dictates a year of technical initiation in order to acquire basic knowledge of the equipment and techniques, coupled with the implementation of tools in mechanics and electronics and an approach to product marketing. The two years making up the second degree represent a period for gaining technical experience. Each year, pupils are required to experience two contrasted project sequences (to be chosen from among the following: assembly and packaging of a product, mass production after prototype-building, design and building of a prototype, product testing and improvement, diversification of a product range, and service provision). During these project-directed activities, pupils are asked to perform several tasks with references to various types of actual firms or companies (industrial or service). The mass production scenario, for example, proposes different tasks, including the temporal and spatial organization of production, cost calculations, and quality control. During the second year of the middle degree program, the service provision scenario offers new activities: a needs-based study, planning and organization, definition of functional purpose, cost estimation, etc. During the final year of the third degree, pupils are assigned to implement

Figure 4. Differentiation and comparison of different technical experiences.



a technical project comprising four main stages: market study, solution search, production, and dissemination.

Throughout the junior high school curriculum, therefore, the principle of progressiveness takes the form of differentiation-comparison (see Figure 4). The first degree provides the basic background of school-based technical activities. The middle degree is centered on the analysis and comparison of technical experiences in the aim of developing a process model. The final degree enables consolidating this general process model and building upon the knowledge and know-how previously acquired.

This progressiveness has been chosen in order to add greater consistency to the school discipline. Technology education is a discipline of experience and not one of content. If the curriculum is defined first by a list of skills, talents, or capabilities, this discipline could be progressively organized around a series of graded exercises, yet the pupils' activities would be insignificant.

In order to comprehend the technological world and act within it, in order to identify relationships between products and human needs, and in order to know how solutions are chosen at different stages of the design process, production cycle, or sales chain in light of technical, human, and economic constraints, technology education focuses on development activities that provide pupils with practical experience and a conceptual framework for describing and analyzing the technical and economic world around them. Such project-oriented activities are then progressively compared and refined by the pupils themselves (Lebeaume & Martinand, 1999).

Designing the Implementation of Technology Education

Thanks to its various features, technology education only exists in the classroom in the presence of teachers and pupils. This truism, however, implies two critical points:

- A program structure in compliance with a standard and a prescription that incorporate the innovation necessary to develop the school discipline and that allow for different types of implementation, depending on both the context and the heterogeneity of the student body.
- The choice of the contents of teacher training in order to enable teachers to discuss their teaching, according to the features and the principles of the school discipline, and to provide their classroom presentations with responsibility and awareness.

The French educational context, which features a national curriculum determined by the Education Ministry, acts to influence the structure of teaching standards. As opposed to the UK, for example, the French system does not include a national assessment based on standards for each year and for each program component. According to pedagogical tradition, technology teachers implement their discipline with a wide degree of freedom. They are allowed to draw up their lesson plans and orient their teaching in a way they feel to be the most effective. It is thereby essential for learning assessment to be integrated into the foundations of the discipline. Technology education, defined as a discipline structured by technical experiences and practical tasks, requires an assessment in accordance with this set of principles (Lebeaume & Martinand, 1998, 2002). New programs identify three components in assessing pupils: participation and involvement within a teamwork setting associated with a project assignment; skill development associated with these particular tasks; and mastery of a few basic skills required for all pupils upon completion of each degree, in order to pursue the next higher degree program. At the end of the middle degree, they must be able to use measurement tools (e.g., electrical regulator, sliding gauge), operate equipment (e.g., soldering iron, drilling machine), and be comfortable with presentation tools such as scheduling or matrices. In addition to the know-how acquired, a certain amount of knowledge, not defined in words but in ideas,

proves necessary to querying, understanding, organizing space and time, and making choices. From this perspective, examples include syllabus notes, production plans, design proposals, market studies, cost estimations, and product life cycles. Upon graduation from junior high school, the student assessment calls for the presentation of a technical project as a means of explaining decisions and choices and of using computer-assisted tools. Students are asked to establish a relationship with their work and the corresponding technical reality and then to produce an explanation that includes notions such as value, flux, (needs defining) constraints, standards, functions, and market. The complementarity of these three components of the assessment serves to maintain consistency in the discipline. Since project tasks lie at the heart of school activities, the experiences turn out to be more educational than merely skill-building or knowledge-building. Assessment is to be fundamentally included within the school discipline.

Implementation of the discipline also requires compatibility with the highly distinct set of school parameters: facilities, environment, organization, timetable, teachers, and pupils. The “technology” structure needs a certain degree of built-in flexibility. This characteristic is apparent by virtue of the decisions required by the teacher in the choices available as regards technical project components. Teachers have to choose two scenarios from among the three, with this choice depending on the local context. They must also decide on the technical product, the resources allocated, the conditions or constraints, and the stated goals and references (small vs. big firms, familiar or not to the pupils, overlapping or not with school practices). These multifaceted choices thereby generate diverse combinations of the organized tasks and different approaches to technology education. Among the range of technology education formulae, the organizational framework facilitates the maintenance of consistency within the discipline.

However, the existence of this discipline also presupposes new perspectives opened by means of controlled innovation. A school discipline cannot simply reproduce the same activities anytime and anyplace. Hence, innovation within the predominant framework offers significant potential for updating and shaping the future of technology education.

The contents of technology teacher training display the consequences of the fundamental principles adopted by new technology education programs in France. These contents can be organized around three main themes:

- Knowledge of the programs and of the discipline, for the purpose of identifying the broadest decision-making spaces.
- The skills involved in the pedagogical implementation of tasks and activities in conjunction with pupils, facilities, etc., to enable teachers to provide technology education, regularize teaching situations, adapt situations by taking account of pupils' reactions, institutional requirements, etc.
- The skills necessary for critiquing the relevance of academic situations in order to control the technical nature of pupils' tasks, discuss their significance with respect to external references, and defend their orientation in light of the purposes. This aspect relies upon negotiating with the method, its three components, and their relationships.

The contents of this didactic teacher training are not organized into syllabi of vocational techniques, but rather as the ability to deliberate about technology education in its current configuration and perspectives. Technology educators, defined as the specialists in this branch of

teaching, are required to possess expertise in all aspects of the school discipline for which they have been assigned responsibility.

Method Employed at the Core of Technology Education

To conceive of technology education today as a disciplinary curriculum requires certain conceptual tools in order to identify key issues and make pertinent design and implementation decisions. Method provides a means for representing the objectives of the discipline in light of all its features, specific characteristics, nature, and conditions of existence. The authenticity of this discipline is fundamentally necessary because of its educational purpose in the compulsory general school system.

This analysis of the context specific to France also serves as a proposal to other school disciplines and to other countries. It clarifies the fact that technology education exhibits fundamental characteristics and the infeasibility of designing a technology education program with a model imported from another discipline. Its historical evolution and the alternation of methods have revealed the major effects resulting from its marked structural approach.

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International Collaboration in Secondary Level Education

By Dr. Tom Loveland, Dr. Hidetoshi Miyakawa, and Yoshitaka Hirayama

Global Education

Over the last 20 years, the economies of the world have been linked closer and closer together. The passage of the North American Free Trade Agreement (NAFTA) and the creation of the Euro currency in Europe are just two examples of how the world economies are becoming intertwined (McLaughlin, 1996). Transnational corporations have operations scattered across the globe to take advantage of access to raw materials, information, and labor. These corporations recruit and want to preserve their productive global workforce (Branson, 1998; Franks, 1998). The largest transnational corporations have budgets greater than many individual countries. The world is viewed by these corporations as a single global marketplace (Branson, 1998). The increasing vitality of the global economy has meant change for countries, businesses, and workers. Countries find that they no longer have

total control over information and their local economies. Autocratic countries such as China and Iran are trying, unsuccessfully, to block their citizens' access to information through the Internet. Economic meltdowns in Argentina and Thailand in the late 1990s had far-reaching impacts on the economies of other countries. Businesses find that they have to adapt to the new business world or fade into obscurity. Workers find that they need new skills to compete globally.

The interconnectedness of the world has been aided by the proliferation of personal computers and the Internet. Inexpensive e-mail allows people from different countries to communicate instantaneously with each other. Organizations, educational institutions, and governments have contributed to the explosion of cross-border information exchange.

These changes and new realities have been described as a new age of interdependence. This interdependence evolved from world trade and international capitalism (Hughes & Ortero, 1989). Interdependence is most evident in the areas of international trade, environment, politics, telecommunications, transnational corporations, and international travel (Fish, 1982). The new global culture is placing new demands on the people of the world. Production is no longer restricted to geographical location so workers need to be more globally astute. According to Scarborough (1991), citizens need to understand the changing technologies, workplace adjustments, and competitive pressures. Fish (1982) confirmed this by stating that people need to be more aware of and more effective participants in the global economy.

Lauda (1992) declared that students throughout the world are internationally undernourished because education systems are too narrowly focused on rigid content areas and national issues. Globalization is a focus that the business world has embraced while education has tended to be more inwardly focused (Scarborough, 1991).

Global education is the means to teach the world's citizens about the globalization trends. According to the U.S. government report *Critical Needs in International Education* (National Advisory Board on International Education Programs, 1983), "it is in our schools, however, that the greatest progress can be made. International and intercultural studies should receive more attention and higher priority" (p. 7). The report goes on to promote the learning of international awareness, cultural sensitivity, and communication skills from foreign language and intercultural studies. Franks (1998) found the following:

As the world grows increasingly interdependent, we discover even more opportunities to learn and work from each other about cooperative education. All over the globe, nations face a critical need to develop and maintain a supply of their most valuable resource: trained and productive workers. Work-integrated education has emerged as a viable means to that end. (p. 72)

High school students are preparing themselves for college and future careers. Students in discrete subject courses are not given the bigger picture about the internationalization of the world. Students miss the connections of how all of these areas are interlinked. An opportunity exists in the schools to solve this dilemma. Secondary-level technology education classes offer a curriculum that encompasses the study of technology with links to all academic classes. A technology education lab filled with Internet accessible computers and equipment is the best location to use distance learning tools and research to create a curriculum that teaches students about international culture, values, and understanding. This program is accomplished by creating a collaborative program for the students to unite with partners in other countries. The goals of this collaborative effort are to teach students in both countries to be more respectful of each other's cultures, to create long-term friendships between the teenagers, families, schools, communities, and countries, and to see the relevance of studying global issues and perspectives. McLaughlin (1996) summarized the importance of global education by stating "global education attempts to teach people how to live in a world that is increasingly interconnected and interdependent. This method of education works to establish cross-cultural understanding and to develop cooperative attitudes needed to solve world problems" (p. 15).

The Japan-Florida Teens Meet Project

Yumegakuen High School or Dream High School in Tsu City, Mie-ken, Japan, was established in 1997 as the first school in Japan that has comprehensive courses as a forerunner of Japanese education reform. High schools in Japan offer either academic courses for students who go on to university studies or vocational courses for students who go into immediate postsecondary employment. The new comprehensive courses at Yumegakuen High have led to a mixture of students and curricula that is unusual in Japan. Due to this educational reform being conducted by the Ministry of Education, Culture, Sports, Science and Technology (Monbusho), Yumegakuen High School is equipped with high tech computers and telecon-

ferencing facilities. An international studies teacher at the school was looking for a partner school in foreign countries and registered the classroom at the Web site of ePALS (<http://www.ePALS.com>). ePALS is dedicated to creating partnerships between schools across the world. When the teacher signed up in October 1999, there were 36,000 classrooms registered. As of July 2003, 81,514 classrooms were registered.

Several weeks after this teacher registered with ePALS, a technology education teacher from Ridgewood High School in New Port Richey, Florida, wrote to suggest a collaboration. It was a very nice and interesting offer because besides the educational purpose of the teleconference, the American teacher showed understanding toward the idea of promoting the school's image within the local community. The school is new and relatively unknown in the community of Tsu-City. It was thought that the collaboration could help recruit good students who would be suitable for these wonderful facilities.

A video teleconference test was held on November 18, 1999, for the two teachers to meet live to discuss curricula and ideas. The students in the two classes decided to call their collaboration the Japan-Florida Teens Meet Project (JFTMP). Activities were developed for the students to work on group projects and individual assignments. On December 14, 1999, students with guests met their overseas friends for the first time live through a video teleconference. This event included welcoming statements by the two school principals, introduction of guests (school board members, parents, district technology supervisors, reporters), some student activities, and question/answers. One of the activities the students did was a math dollar/yen conversion exercise. Students researched what the current conversion rate was and then calculated the cost of teen merchandise in both dollar and yen denominations. Comparisons were then made about the availability and costs of items the teens were interested in. The teen items were randomly pulled out of a hat to add some excitement to the event. This first teleconference was a great success and the media favorably reported it.

In late spring of 2000, plans were presented to the students about an international space station project. American and Japanese students would work on transnational student teams to conceptualize, research, design, and construct a 1/20th scale model international space station. The students had to design a sustainable environment built for teenagers living long term in space. The teams focused on essential modules of the international space station: living space, water-based systems, command, solar power, and scientific experiments. Two initial balsa-wood modules, including command and water-based systems, were completed by the American students and shipped to Japan in early June 2000. During the 2000-2001 school year, advanced technology studies students completed the rest of the modules for shipment to Japan. The design of the international space station modules was developed using a WebQuest format. This was placed on the World Wide Web for students and parents to access outside of school. The main JFTMP Web site is at <http://www.tcp-ip.or.jp/~hirayama/jftmp>.

Two teleconferences were held in the fall of 2000. New students in both countries were introduced to each other. One of the teleconferences included 100 fifth graders from a local elementary school in Tsu City. A Japanese foreign exchange student at Ridgewood began participating, adding to smoother communications and understanding. Over the next several years, media in both countries reported about the teleconferences and collaborative activities. Yumegakuen High School received good publicity and attracted more students. In the spring of 2000, about twice as many students took the entrance exam than there were openings for admission.

In January 2000, the American teacher received a grant from a local foundation to travel to Japan in the summer of 2001 for two weeks with eight Ridgewood students. Five of the eight students traveling were from the technology education classes. Two days were used to visit Yumegakuen High School so the students could meet and participate in shared activities. During the visit there, the Japanese and American-built components of the model inter-

national space station were assembled and put on display. The event was covered extensively in the Japanese press. A photo was taken of the JFTMP students that day with their completed model space station. A JFTMP goal was to have that photo flown to the international space station with a Japanese astronaut. A photo of the astronaut holding the JFTMP picture in space would then be enlarged and put on display in both schools.

A decision was made to make a video project the centerpiece of the 2001-2002 school year. The video, *Smoke and Mirrors*, was a dramatic anti-tobacco story that had scenes taped in both countries and in both languages. Two different versions of the video were produced. In addition to memorizing their English dialogue, the American students had to learn Japanese for the same scenes. The Japanese had to learn their lines in Japanese and English. American students edited the English-only version and the Yumegakuen students edited the Japanese-only version. Both videos were premiered during a teleconference in March 2002. The videos were partially funded by the Students Working Against Tobacco (SWAT) organization in Florida.

The Future of JFTMP

In addition to the video projects, the teachers are collaborating on expansion of the JFTMP Web site. They are working to include more schools in their international collaboration because of their belief that high school students benefit from this experience. American students are taught critical thinking skills, but Japanese students are expected to be docile. Now in the age of information technology, Japanese teachers are beginning to realize the importance of critical thinking. Japanese businesses are realizing that having docile workers is not helpful to their companies in the global economy. This doesn't mean the companies need argumentative workers. They need workers who think differently and share their ideas. These different ideas can be used creatively by the companies and/or classrooms to generate better ways of doing things. This is how society can improve. The JFTMP is designed to make the most of international collaboration and friendships.

Obstacles to Collaboration

There are obstacles to the success of international collaborations. According to Weinbaum and Rogers (1995), "such projects require a rethinking of traditional school schedules, as well as providing opportunities for teachers to learn new material, design curricula, plan with their colleagues, and reflect on the effectiveness of their practice" (p. 22). Obstacles in the JFTMP program were summarized into several categories: time difference, school year schedule, language barriers, and difference of interests.

The prime obstacle was the time difference between Florida and Japan. This obstacle was overcome by the Americans coming back to school in the evening to meet live with their Japanese partners who were in their regularly scheduled first period class the following day. The Japanese don't observe daylight savings time so it became important to check an international time zone Web site to make sure the meetings started at the correct time.

Another obstacle was the difference in school schedules. The school year in Japan starts in April, whereas American schools start in August. JFTMP started in 1999 and some of the active Japanese students have already graduated from high school and are now studying at college. When the American students came to Japan, most of their e-mail friends had graduated. A secondary goal of the JFTMP Web site was to keep graduates informed about current collaborative activities.

Some challenges were related to the nature of the distance learning technologies themselves. The use of ISDN lines cost the schools about \$200 per teleconference. The two schools shared responsibility for these costs although both schools had to justify the phone costs to administrators outside of their schools.

Language was a major source of concern prior to the teachers talking live with each other. It was helpful to the Americans that the Japanese teacher fluently spoke English. Ridgewood High is in a rural suburban area with little opportunity for native Japanese

speakers for translation assistance. The language barrier is a continual hurdle, but English is the target language for Japanese students to learn so this is a part of the purpose of education and the teleconferences.

Another challenge was in the shifting interests of the students. Yumegakuen is a mix of high school and adult learners. Some of the adult students were mainly interested in learning about foreign cultures and English rather than mechanical projects such as the space station. The JFTMP program shifted with the American teacher from Ridgewood High School to Marchman Technical Education Center beginning with the 2002-2003 school year. The newly linked Marchman class was television production so the teachers agreed to focus JFTMP ideas towards video projects. This shift appeared to satisfy the interests of the adult and high school age students at both schools.

Due to a lack of curriculum materials on international collaborations at the secondary level, the teachers found that they had to develop and write the curricula themselves. Plans are underway to expand the core schools to include more Florida and Japanese high schools into a larger JFTMP consortium. This will expand the curriculum resources for all teachers through the sharing of ideas and experiences.

Information Technology Education in Japan

According to Miyakawa (1998), current advancement in communication technology is allowing for ever increasing access to information. This not only promises to change people's life styles, but also may change the value system of society itself. In such a "technological" society, those who can readily adjust to these changes into technology will do very well while those less able to adjust may be left behind in the information revolution. (p. 29)

The information society is highly advanced in Japan as it is in the United States. The information technology revolution in Japan is pressing leaders to consider how to manage the information society in all fields including industrial

technology, business, society, and home.

Schools are no exception and are now trying hard to adjust to the information society. School computers are becoming networked so the worldwide Internet is becoming more available. It is therefore important for the education field to promote effective and efficient use of computers and to develop new learning content and curricula.

Information technology education in Japan began in 1985. It has been promoted aggressively and continuously since then. Various policies have been adopted such as distributing money to school education budgets and training teachers through in-services. As a result of this investment and the support of Japanese parents, almost all Japanese students take information technology education, a lowersecondary level elective.

In 1999, surveys conducted by Monbusho showed the state of information technology and computer usage in Japanese schools. Ninety-nine percent of the 39,096 schools had computer equipment. Of those schools, 22,449 were connected to the Internet. Internet guidelines have been established in 9,477 schools. The number of schools with their own Web site was 7,850. Among the 38,829 schools with computers, 27,205 were connected by LAN.

Of the 886,768 Japanese teachers, 66% can operate computers and 32% can teach using computers. The subject area with the highest usage and ability to teach using computers is in technology education. Of the 10,541 technology education teachers, 94.5% of these use computers.

There are issues that affect the ability of Japanese schools to participate in collaborative projects with schools overseas. Monbusho is addressing these with the following implementation schedule for information technology:

1. All public elementary, lower secondary, and upper secondary schools were connected to the Internet by the end of 2001.
2. By 2004, LAN networks will be installed in all public schools.
3. By 2004, all private schools are targeted

for Internet connection.

4. All 900,000 public school teachers took an in-service Project for Enhancing Teacher's Information Literacy by the end of 2001.

In addition to Monbusho's plans, Japanese leaders in the technology education field have raised seven other information technology issues that should be addressed by educational institutions. Hardware that has functions required for school education should be equipped in all classrooms that need it. It is necessary to make computer equipment available for anytime, anywhere, and anyone. Effective and efficient educational software should be researched, developed, and distributed at low prices to schools. Educational objectives about information technology should be clarified and all teachers should examine the new content and methods. Connection charges to Japanese schools should be substantially reduced. Teachers and students should be thoroughly taught ethics and morals in the appropriate use of the Internet. Finally, teacher training in information technology should be planned and conducted according to the needs of teachers. Steps like these can lead to more connections between technology education classrooms in Japan and the rest of the world.

Benefits of Collaboration

There are two major benefits of international collaborations: the learning is authentic and contextual-based, and student motivation to learn increases substantially. Authentic instruction is a way of linking classroom work to real work situations that employees face out of school. Blank (1997) referred to authentic instruction as "any instructional strategy, model or technique that involves students in learning something that is useful or important beyond the school setting and that engages them in a manner that helps them construct new knowledge or develop deep understandings or insights" (p.15). It is a teaching strategy and project-based curriculum that mirrors work that adults perform in their employment, home, or community. Weinbaum and Rogers (1995) pointed out that situating education in real-life contexts is an answer to the concerns of vocational program critics who feel there is a gulf between what is

in education and what the actual human resource needs are of the U.S. economy. Resnick (1987) concurred by recommending that schools concentrate on teaching people to be adaptive learners able to negotiate the inevitable transitions that occur in the workplace.

High school graduates will be facing a far different work world and will therefore need to learn in far different ways in the classroom. Global education was chosen as an overall theme to enable students to work on real-life projects that increase problem-solving skills, create unique team settings, and help students become better communicators and international citizens. The two JFTMP teachers directly observed many benefits to the students and schools from participation in collaborative projects.

For students:

- Increased technical skills.
- New understandings of applied math and science.
- Better writing and communication skills.
- Increased technological literacy.
- Increased classroom motivation and excitement about learning.
- New concepts of what a "team" means.
- Less stereotyping of other cultures.
- Broadened student views and perspectives.
- Understanding on the implications of the global economy.

For schools:

- Enhanced parental support.
- Opening communication lines with other education systems.
- Awareness of the advantages of using new technologies.
- Promotion of new and creative school curricula.
- Raised education standards at local schools.

Planning an International Collaboration

High school teachers interested in initiating an international collaboration with a school in a different country face many challenges. Using the Decide phase of the DDD-E model (Barron & Ivers, 1998), teachers can systematically develop authentic learning, multimedia projects

with teachers from other countries. The broad challenges that face teachers during the planning section include:

- Fitting the project within the scope of district and state curriculum mandates.
- Finding a sister school with similar interests, curricula, and distance learning technologies.
- Assessing their school's distance learning technologies.
- Developing the prerequisite skills to use these technologies.

Setting Instructional Goals

The first task for the teacher is to set instructional goals. According to Barron and Ivers (1998), instructional goals may include responding to different student learning styles, promoting cooperative learning, enhancing vocational-academic integration, developing critical-thinking and problem-solving skills, and fostering presentation and speaking skills.

Broad and content-specific instructional goals were developed for the JFTMP collaboration. The first goal of the collaboration was to prepare students for careers in the global economy by having the project mirror projects done in the workplace. Broad instructional goals for this collaborative effort were to teach students in both countries to be more respectful of each other's cultures; to be more aware of the cultural differences; to create long-term friendships between the teenagers, families, schools, communities, and countries; and to see the relevance of studying global issues and perspectives.

Deciding on the Project

After developing the instructional goals, the teacher now selects and designs a multimedia classroom project. International collaboration projects are complicated and require comprehensive preparation and design. Teachers have the choice of joining an education-based network with developed curricula, projects, and preselected international classrooms or develop their own original international collaboration. According to Bradsher (1996), "identifying overseas schools with the means and desire to pursue a project that fits your curriculum and students' needs and interests can take a lot of time" (p. 50). Before contacting a teacher from overseas, the American teacher should study the culture and education system of the country he or she wishes to collaborate with. Initial studies

will help to increase the teacher's cultural sensitivity, knowledge of the other education system, and make for a more polished introduction.

It is important for teachers to communicate openly and clearly about goals and project ideas with their partners. Projects will need to be started in incremental steps for several reasons. Overly enthusiastic American teachers may be intimidating to teachers from other cultures. Education systems in other countries may have their coursework rigidly set by a national curriculum that makes it difficult to accommodate comprehensive collaborative projects. Finally, other cultures may be used to thoughtful, team-based decision making. American teachers will need to be aware of and respectful of these differences.

Development of Prerequisite Skills

The third stage of the decision process is to develop the prerequisite multimedia skills within the teacher and the students to improve the project's success. These skills may be technological and related to global communication.

Thach and Murphy (1994) found that

the distance learning instructor needs skills and knowledge in eight major areas: 1) communication and feedback, 2) promoting interaction between and among learners, 3) teamwork and collaboration, 4) administrative and support services, 5) conducting learner needs assessments, 6) distance learning technology and its impact on learners, 7) identifying learning styles, and 8) developing a systems perspective of thinking. (p. 16)

Distance learning technologies include Internet (research, e-mailing), desktop teleconferencing (NetMeeting, CUCMe), video teleconferencing (Picture-Tel, ISDN lines), and interactive multimedia (PowerPoint, Web page design). The teacher should take in-services or classes or use study time to master these technologies before attempting to teach them to students. Fortunately, American students have been exposed to and have access to many of these technologies. In some cases, the students will be the expert and the teacher the learner. All students should be familiar with basic computer skills and the skills required for the specific multimedia project.

American students will need an introduc-

tion to and practice in global communication skills. Their written communication with partners through e-mails will need to be clear, concise, and punctuated properly. During the video teleconferences, normal American teenage habits of wearing baseball caps, having arms folded, using slang, or wearing provocative clothing may be seen by foreigners as extremely rude and offensive. When speaking with non-native English speakers, it is important to slow down, not raise voices, and give plenty of time for translation. Students will need to be made aware of these communication skills. The importance of projecting a friendly, team-oriented image with respect for cultural diversity can not be overstated.

Assessing Resources

At this fourth stage, teachers begin looking at their classroom resources to see if there are hardware or software gaps. They would begin by thinking about how many computers they will need to keep the students productive. They will need to know how many of the computers will have Internet access. What level of Internet access should the teacher allow the student is another important question. If Web sites with classroom photographs are being considered, a copyright talent release form will have to be written and distributed to parents. Teacher funds may need to be set aside for the cost of the ISDN lines used during teleconferences. Overseas mailing costs for curriculum materials will have to be arranged. Software might have to be installed and tested. If the computer and distance learning technologies are outside the classroom, the teacher will have to set exact times and schedule these with the schools in both countries. The teacher will also need to investigate educational Internet sites for resources. The technology studies teacher spent countless hours looking at NASA sites on the international space station. Before writing URL addresses into student handouts, a teacher should check all to make sure they are still operative.

Conclusion

The use of computer-mediated communication is increasing exponentially in the United States. Whether schools realize it or not, this increased use of technologies works to engage learners in ways that increase understanding and student success. When instructional techniques enlist more than a learner's logical/mathematical

intelligence, student motivation to learn increases. Students experience success and conclude that school is relevant in their lives.

When global education, international collaboration, and authentic/applied learning projects are incorporated with increased use of computer-mediated communication technologies, student interest and motivation to learn is enhanced. All students, gifted to specific learning disability, can benefit from exposure to this instructional strategy. The role of the teacher is crucial. Instructional strategies should be designed to include computer-mediated communication technologies. The benefits to students far outstrip the planning that is required. Computer-mediated communication can form a powerful integrated model of human learning and intelligence. This model provides teachers with the tools to meet high standards. The outcome of comprehensive planning is students with better attitudes and understandings of the cultures and values of students in other parts of the world. Students will become lifelong learners, adaptable to change, and better prepared for their future work and careers.

In the initial phase of an international collaborative project, the teacher will need to work diligently to plan and organize before presenting the project to their students. This planning stage includes setting the instructional goals, deciding on the project, developing prerequisite skills in themselves and their students, and assessing their resources. The benefit of this planning will be an international collaborative project that affects learners and teachers in profound ways. According to Jensen and Loveland (2000), "when learning environments mirror the restructured work that students will eventually enter, they provide students with opportunities to see how what they are learning in school adds value to their lives" (p. 371). The new interconnectedness of the world is a reality that teachers can utilize to develop projects that will prepare their students for the career world they will be facing upon graduation. According to Thach and Murphy (1994):

Suddenly, separate cultures, laws, regulations, and customs have been brought together in a kaleidoscope of learning. The result is chaotic, fun, challenging, and anxiety-producing; it challenges all of those who work in the field of distance education

to broaden their perspectives, to strive for the implementation of best practices; and to encourage collaboration while respecting individual, group, and institutional integrity. (p. 17)

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Secondary School, University, and Business/Industry Cooperation Yields Benefits to Technological Education Students

By Dr. Ann Marie Hill

Political Dimensions of School and Community Cooperation

The secondary school work environment of technological education teachers in Ontario has changed. These teachers cope with pressures from the Ontario Ministry of Education (OME), business and industry, and the public at large for increased community involvement in education and for relevant student learning that is connected to life outside of school. This is what Ruddick (1999) referred to as the pressured, political dimensions of partnerships. Many reports have portrayed this dimension of partnerships at the national level in Canada (Dave, 1976; Dryden, 1986; Human Resources Development Canada, 1994, 1995) and at the provincial level in Ontario (Premier's Council, 1994; Royal Commission on Learning, 1994a, 1994b, 1994c, 1994d).

In Ontario, a past policy document (Ontario Ministry of Education and Training [OMET], 1995) for secondary school technological education introduced the concept of partnership. One chapter, titled "The Learning Environment," consists of four subsections: the facility, resources, the role of the teacher, and process and project management. The latter subsection states:

It is necessary for students to move to different areas in the school or out into the community in order to complete projects. The teacher will need to work in close co-operation with all stakeholders (students, parents, community members, other teachers, and administrators) to co-ordinate the contributions of all those participating in the students' activities and to address any concerns related to them. (p. 13)

The next chapter, titled "Considerations in Program Development," consists of seven subsections, one of which is school-community partnerships. This subsection argues:

In order to maintain and strengthen their connections with the community, schools must involve community members and groups in its planning, delivery, and evaluation of all broad-based technology programs. Schools should consult with community representatives on a regular basis in order to identify new needs as they arise and allow programs to be adjusted accordingly. (p. 16)

A new policy document (OME, 2000) now replaces the 1995 document, but the idea of partnerships remains.

In general, technological education programs should be designed to take advantage of local opportunities for students to combine work experiences with classroom learning. Programs may be modified to reflect community needs. In-class and out-of-class components must be carefully matched and monitored so that students' experiences are relevant and authentic. (p. 200)

Community-Based Projects in Secondary School Technological Education

Research in technological education (Hill, 1996, 1997, 1998, 1999) has documented that it is not solely the project that is important in project-based learning. While the project provides the environment for students' active engagement in their learning, the teacher alone frequently

defines the project. The experience of making such projects may not be directly relevant, authentic, or meaningful to students' lives. Dewey (1977) stated: "It is not enough to insist upon the necessity of experience, nor even activity in experience. Everything depends upon the quality of experience" (p. 27). He described two aspects of quality: "There is an immediate aspect of agreeable or disagreeableness and there is its influence upon later experience" (p. 27).

Projects become more meaningful to students when the technological problem-solving experience is situated in and relevant to their lives, such as involving them in the community in which they live. A real-life context sets real human needs for projects and this in turn establishes relevant activities for authentic learning. The learning environment in this approach shifts from a situation of project-based learning, which is typically teacher conceived and of less interest or relevance to students, to community-based project learning, where students are involved in projects from their community, called community-based projects. The community is typically the immediate community serviced by the school, but it can expand beyond local geography. Community partners can be business or industry—large or small—which are located in the community, local families, the school itself, or the school board. Students design projects for community partners, and the community partners provide resources and expertise to students.

A community-based project approach to learning allows students to meet real human needs in their technological education courses; they carry out technological design for an identified need of a community member. Such projects encourage working cooperatively with people inside and outside of school. As students meet with their community partners and with experts in the community, they recognize other people as important learning resources. They also become motivated and engaged in their own learning. Programs that reach out to the world outside of school provide a means for relevant student learning and a stimulating and viable educational experience for students. The gap between school and life outside of school is also reduced as students see applications for what is learned in school and are presented with a new range of choices and opportunities from

these community experiences.

Community-Based Projects Applied in a Manufacturing Technology Program

Hill and Smith (1998) examined a secondary school in southeastern Ontario where graduates and others familiar with the setting spoke highly about a particular program and the teacher who had received national recognition and teaching awards for his work in the school. The teacher's program in technological education consisted of courses in Manufacturing Technology, Grades 9 through 12. One Grade 10 class and one Grade 11 class were studied intensively during a five-month period.

The Curriculum

The curriculum content for both Manufacturing Technology courses, Grade 10 and Grade 11, included: the technological design process, interpreted as a problem solving process; mechanics (stress and strain, strength of materials, gears, pulleys and belts); power systems (electrical, pneumatic, hydraulic); control theory; skills building using tools and equipment (including computers); and group work. There were also different community projects ongoing simultaneously in any one course as students worked in groups with different community partners.

Community-based projects during the year of the research ranged from bike cars, a bike trailer, and classroom objects for teaching technology at local elementary schools to projects with local business and industry. A gardening table and a laundry bin device were created for a local retirement home, and a spool rewind system prototype was created as part of the production process of a large multinational tire producer.

The Teacher

The teacher had worked as an engineer in a large multinational firm and had changed careers to become a teacher. He had begun his teaching career teaching physics and mathematics and after several years became a technological education teacher. His main reason for the change was that the pedagogy used in technological education courses "fit" with his philosophy of teaching. In an interview, the teacher described the impact that the change in subject area assignment had had on him, and his adoption of a project-based approach to teaching that included community involvement:

I started teaching in the conventional manner. I was at the front of the class, you know, going away at a bunch of people sitting in front of me, and...my sense of what I got back was that people weren't learning. True, they were able to regurgitate, but that's not learning. They weren't learning. It wasn't registering....The material was fine, but somehow it just didn't have a context, and I was beginning to think about ways, at that point, about how to make it relevant to the kids....I think the context is really the important thing....You know, just teaching the physics or a mechanics principle in pictures doesn't compare to somebody going and picking up something, pulling on it, and then by drawing a little sketch...just having that tangible holding-on contact makes all the difference to me. And so it grew there. I started thinking, well if that's the case, why don't we try building something, and [I] began a long process of learning how to do that. (DH,¹ personal communication, March 13, 1996)

He described "learning in context" as "being able to put together the doing something and the understanding of doing something." His example of what he meant was based on life experience. "I was doing physics problems with my daughter...after doing a bunch of problems on paper, little pictures—I asked her 'What's that for?' and she didn't have any idea...that's why I say...it's not understanding...it didn't have connection to the kids' lives" (DH, personal communication, March 13, 1996). His life experience had led him to technological education where he involved the community in student projects in order to create a learning environment where students could learn in a context that was connected to their lives.

The Students

The students in these two classes were both male and female with a wide range of interests and abilities. The Grade 10 Manufacturing Technology class consisted of 14 students: 12 male and 2 female. Grades on completed courses toward an Ontario secondary school diploma (OSSD), across all subjects, ranged from 51% to 95% for the males and 78% to 96% for the females. The students' age varied from 16 to 19

years. There were 19 students enrolled in the Grade 11 class: 14 male and 5 female. Their grades on completed courses toward an OSSD ranged from 23% to 97% for the males and 62% to 100% for the females. This group had completed more OSSD courses. As well, their age range was more uniform ranging from 17 to 18 years. Student interviews from both grades revealed that students enrolled in the course for a variety of reasons: from gainful employment directly related to the technological education course to continuing on to university engineering programs.

Benefits of Community-Based Projects to Secondary School Students

Community partners, the school principal, and students all commented on the benefits of school and community cooperation in the delivery of technological education at the secondary school level.

Community Partners' Perspectives

There were many community partners associated with the Manufacturing Technology courses. Data from one large-sized company and one medium-sized company are reported below. Both reveal similar perspectives about the knowledge, skills, and values deemed important for high school students and how partnerships assist students to close the gap between school and life beyond school.

Large-sized company. A major international tire producer had worked with the secondary school for several years. Company contact people assigned to work with the school were selected for their technical abilities associated with class projects. One assigned contact person described his role in the cooperative project for that year: "I present them with the problem and allow them to come up with their own ideas without telling them what I think is the solution" (SD, personal communication, March 22, 1996).

Initially he described the skills, knowledge, and attitudes needed by students graduating from high school in terms of generic skills such as the ability to be flexible, solve problems, deal with any situation effectively and in a timely

¹ For purposes of anonymity in this qualitative study, pseudonyms in the form of initials were assigned to represent real names.

manner, continually adapt and learn, and work with other people on a team. He stated that specific skills were best learned in the workplace. "I think that technique and the ability to do, that is more what they learn [in the workplace]" (SD, personal communication, March 22, 1996).

When asked to explain why specific skills should be learned "on the job," he provided more detail. "The need for specific skills... is going to be really dependent on where you're trying to place them in the company." He explained that if an employee were hired as a welder or an electrician, he would hire "somebody who has some sort of detailed [skills] background." As such, the company would expect the applicant to bring these skills to the job. However, when an applicant was hired to work in production, the company provided specific training. "If you're talking about a lot of our production jobs, the skills that are involved are not things that you would normally learn from an educational institution," because the skills required were specific to that company's production process. When he described qualities of applicants who were hired to design and implement company projects, he said, "Then in my opinion you're looking more at a problem solver who works with other people" (SD, personal communication, March 22, 1996).

He cautioned against only specific skills training in secondary school. Instead, he described the role of secondary school technological education courses in terms of generic skills. "So the most important thing in my opinion wouldn't be learning a particular function or craft or whatever. It would be becoming generally knowledgeable and flexible, to be able to adapt, to learn" (SD, personal communication, March 22, 1996).

In discussion about students obtaining specific technical abilities while participating in community-based course projects, he recognized the importance of technical skills to make the artifact and generic skills to work in a group and move through the design process. He also recognized the value of creativity in these projects and the confidence that such a process instilled in students. "It's the getting there and the learning it...and getting the confidence of, 'Hey, I can do this! I can do more!,' that attitude" (SD, personal communication, March 22, 1996).

Clearly, it was not only the acquisition and refinement of generic skills that moved student projects to completion. Knowledge and skills from many different technical areas were required for project completion. This large company also required, for certain jobs, skilled and technical employees, but even these individuals needed generic skills as well.

Medium-sized company. Interviews with the contact person from one medium-sized company, a retirement home, also revealed a need for generic skills in the workplace. This work environment used a different model for teamwork. First, all employees were part of a team. Second, the teams were comprised of people with different skilled backgrounds who worked together for a common goal—"to maintain the quality of life" for each elderly resident. "All our teams are composed of maintenance, housekeeping, health care aides, psychologists, right up to the administration. Every committee has those people on it" (LA, personal communication, March 22, 1996).

The contact person for this care agency described that while she brought to the team a skill, she was also required to move beyond a narrow job description when needed and to change her skills as the job evolved. She described job requirements as flexible ("My job here is housekeeping...but I also do other things...the cleaning staff [are] very involved with the residents...with the residents' care—emotional care"; LA, personal communication, March 22, 1996) and as requiring on-going education ("We have to attend care conferences.... Your job is not always what it appears to be"; LA, personal communication, March 22, 1996). She saw her role as sharing this with students, as well as providing them with project possibilities to better the life of the residents.

The School Principal

The principal was very supportive of all students' life goals. He believed in making school relevant so students' secondary school education would be meaningful to them. When talking about the qualities important for graduates, the school principal saw three important areas of an adolescent's development: personal qualities, general qualities, and specific skills. Personal skills were described as a sense of responsibility, recognition of the importance of learning, and honesty. General skills were described in terms of literacy, numeracy, science

literacy, technical literacy, computer literacy, and data processing.

He talked about specific skills in the context of students in their senior high school years and students moving toward employment. Here, he pointed out the necessity and importance of specific skills. "If you've got two students going for a job in autobody...they both have the personal skills that allow them to function in the workplace. Who is that employer going to hire?...Well, my experience tells me they are going to hire someone with specific skills" (MD, personal communication, March 3, 1996). The principal recognized that school-community partnerships provided benefits to students. They provided relevant learning opportunities for students and helped close the gap between school and life beyond school.

Students

Both Grade 10 and Grade 11 students appreciated their Manufacturing Technology courses for the relevance the courses brought to their learning. The teacher's reasons for engaging in this approach to teaching were qualified by what students said.

Grade 10 students talked about the benefits of community-based projects in their course. Their comments revealed that the course affected their learning in other subjects and their overall secondary school experience. They used words related to not boring ("constantly do different things," "moving around," "not formal," "you don't actually realize that you're learning") when talking about the course. They indicated that in learning by doing, the course was like real life and that the theory and practice combination made their learning more challenging. Community-based projects were described as providing varied, not narrow, experiences and that the combination of theory and practice afforded in community-based projects made learning relevant. "It gives you like, you know how school is. School, and then you want to grow up, and leave, do other stuff that has nothing to do with school. Both together, you don't feel like you are doing it for no reason. Like most schooling is" (SA, personal communication, December 5, 1995).

Grade 11 students revealed similar benefits of community-based projects in their course. As well, they were cognizant of the social benefits of community-based projects. "If we didn't

do it, then a lot of things wouldn't get done [in the community]" (HI, personal communication, November 17, 1995). "It's profitable for both people. They [the community] get something that they can use, that they need, and we get the experience of building it, of working on it for an entire semester" (JE, personal communication, November 17, 1995). They also appreciated the challenges that this course offered them and they were aware of how it contributed to their plans for life beyond school.

These courses benefited students in more ways than just narrow skill acquisition. Problem solving, decision making, creativity, teamwork, social responsibility, trust, and continuous improvement and learning were evident in the community-based projects.

Impact of Community-Based Projects on Teachers

Course delivery through cooperation between secondary schools and the community has a direct impact on the day-to-day life of teachers. Hill and Hopkins (1999) wrote that from the teacher's perspective, it is feasible to use community-based projects in secondary school settings. One important factor is simply to get started by establishing links with the community. Once this first step is complete, additional opportunities arise by word of mouth.

Structurally, there is very little change to a school day with this approach. There is the same number of classes per day and teachers still have to prepare for their classes. What changes is how teachers go about their teacher lives. Each day, each class, each period is never the same, never repetitive. Students' needs and activities are never entirely predictable. However, the curriculum is predictable. Course content guides the course, but activities used to learn the content are not as predictable. At the onset of a course, the teacher spends a substantial amount of time thinking about how to match course content to community projects. Once projects are selected, the teacher must carefully schedule student acquisition of content to advance student projects.

The classroom setting also changes with this mode of delivery. There is a need for a technology laboratory or "shop" area, whether within or separate from the classroom. In addition, the teacher's workplace moves beyond only

the school and classroom/laboratory setting into the community. Community members both attend class and are part of the course. Also, students and teachers go to community settings. Human and nonhuman community resources of all kinds are sought out and used. Thus, teachers relinquish a more authoritative role in their classrooms for the role of facilitator.

The teacher's role changes significantly in this model from the conventional transmitter of knowledge to the facilitator of learning. The purpose for student learning is not because the teacher wants students to learn something, but because students need to learn to advance their community-based projects. The focus of class time is on the learner. The learning environment becomes more interesting for students and challenging for the teacher. The challenge is to develop the confidence to be a risk taker and to go beyond the boundaries of convention.

However, this pedagogical approach does not come without added pressures for teachers. There is pressure to succeed on various levels. Projects must successfully meet community needs and be completed within a negotiated time frame, typically by the end of a semester or at least by the end of the school year in the case of larger projects. The teacher takes on personal responsibility for successful completion of projects. The teacher's reputation and the program's livelihood rest on the teacher's ability to manage such a program. There are also day-to-day pressures that arise from teaching courses where students work on different projects. Attention to detail in the beginning weeks of school is paramount, as evidenced in the following excerpt from the Manufacturing Technology teacher's audiotape journal: "Getting these things set up and organized is probably the most important thing you can do; getting a proper definition of what the technology project is, getting a good relationship with the clients...getting the kids to understand the size and definition of the project" (DH, personal communication, September 6, 1995).

But this teacher believed that a community-based project approach was well worth the effort on his part. Experience had shown him that many students do not learn well in a traditional teacher-centered classroom. He still used more traditional approaches to teaching, for example, a 10-minute lesson at the beginning of class or a small teacher-focused project for

content not covered through community-based projects. However, this represented teaching moments within the activities of the community-based projects, not a main pedagogical approach.

After several years of examining the community-based project approach in technological education courses, new teacher organizational skills and knowledge have emerged, including the ability of the teacher to:

- Have faith in students' abilities to learn. Relax in being a facilitator.
- Teach a short lesson of about 10 minutes at the beginning of every 70 minute class, and then trust and manage.
- Rearrange expectations of the teacher and students, for example:
 - Don't spend too much time with one group, one project.
 - Give students encouragement and clues, and then move to another group.
 - Encourage students to ask the teacher for help when needed.
 - Inform students that if they are waiting for teacher help, or for the community partner visit, etc., they should be doing some other activity while waiting.
 - If students need materials, they are responsible to make a list and give it to the teacher.
 - Inform students they are also responsible for their learning.
- Accept that they do not know everything, that they are not the purveyors of all knowledge for all projects. Students are responsible for their learning also. Then the teacher can focus on managing students' learning and projects.
- Be enthusiastic and energetic.
- Be an on-going learner.
- Use human and resource materials in the world outside of school.

Community-Based Projects and Teacher Education

Teacher education programs can model secondary school classrooms that link with the community. Remembering that artifacts, systems, and processes are supposed to meet human needs, in teacher education courses, teacher candidates would be required to find projects based on community needs. In doing so, they would experience the technological

problem-solving process that they in turn would expect their secondary school students to engage. The community can be inside or outside of the class.

The teacher education program at Queen's University, Ontario, engages teacher candidates in both teacher-directed and community-based projects. In 1995-1996, examples of community-based projects to meet needs outside of the teacher education class were "The Emergency First Aid Backpack," a specially designed backpack to carry emergency supplies and equipment to remote locations; the "Exit Buddy," a device that enables firefighters to quickly locate exits in dark, smoke-filled rooms; "Uropia," a lightweight, portable rope course; "The Art Kart Centre," a space organizing system for elementary school classrooms; and a "Support Table" for last year's project, the "Arm Rehabilitator 2000." Projects that met in-class needs were a "Multimedia Interactive CD," an information program designed for the World Wide Web about Queen's University's technological education program; and an "Information Video on Broad-Based Technology" to introduce high school students, staff, and the local community to the study of technology in secondary schools.

In 1994-1995, examples of community-based projects were the "Arm Rehabilitator 2000," designed for stroke patient therapy at Saint Mary's of the Lake Hospital (Gubbels, 1995), and the "Environmobile 2000," a solar-charged battery land vehicle made from old bicycles and an old chair. The former met an outside community need while the latter met an inside (class) community need. In 1993-1994, projects included an "Equestri-Lift" for physically challenged equestrian riders and a "Wind Powered Generator."

As teacher candidates move through their community-based projects, discussion focuses on the transfer of their university experience into secondary school classrooms. They begin to think through what it means to act as facilitators. They begin to understand the connection between the notion of facilitator, the negotiation of meaningful student projects, and alternative ways to deliver course content (see Boomer, 1990). In the latter, the critical teacher skill is to be able to plan student learning of skills and knowledge to allow students to advance their community-based projects. Teacher candidates also discuss ways to weave values and human and environmental concerns into classroom talk and to provide a learning environment for secondary school technological education students that fosters creativity, exploration, critical thinking, and connections to what is learned in other school subjects and to life beyond school.

Conclusion

Research about school and community cooperation to deliver technological education programs at both secondary school and teacher education levels in Ontario, Canada, has documented that such collaborative classroom practice is not only possible in technological education, but is highly desirable because many modern theories of learning are seen in this educational practice (Hill & Smith, 1998). Collaboration between schools and community partners augments both secondary and university student learning and allows business and industry to give something back to the community from which they benefit.

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Notes

- ¹ This paper is in part derived from research conducted by A. M. Hill and H. A. Smith. The research was supported by a Strategic Grant from the Social Science and Humanities Research Council of Canada (SSHRC) under the theme Science Culture in Canada.
- ² An earlier version of this paper was presented to the International Conference of Scholars on Technology Education, Technische Universitat Braunschweig, Braunschweig, Germany, September 24-27, 2000.



Distance Education for Technology Teachers

By P. John Williams

This article describes a distance education approach that has been developed and implemented in Mauritius, Seychelles, and Botswana to help overcome limited teacher training opportunities and so help meet the demand for well-qualified technology teachers. It outlines the principles of course design, the mixed mode of delivery, and some of the issues of course delivery derived from program evaluations.

Technology in its current form is a relatively new subject; it has a brief history in schools as a component of general education (deVries, 1993; Layton, 1993). In some countries it has derived from vocational programs such as in Taiwan and Australia, and in others it is influenced by craft subjects such as in Sweden. Traditional technology education has also generally been gender biased, with activities designed to reflect gender stereotypes. The new technology education is moving away from narrow vocational preparedness and from gender specificity. The culture of school technology identified in the early 1990s (Layton, 1993; Puk, 1993) is developing, though still in its infancy, into a new paradigm about values, practices, content, methodologies, and capability (Kimbell, 2003).

The developing patterns of technology education in many countries challenge some of the traditional characteristics of schooling such as the decontextualization of knowledge, the primacy of the theoretical and secondment of the practical, and the organization of the curriculum along disciplinary lines. In contrast, technology

education emphasizes the context of the technological activity, learning is achieved through the interaction of theory and practice, and it is interdisciplinary.

Some of the trends in technology education, which are obvious in a number of countries, include a movement from:

- Teacher as information giver to teacher as facilitator of learning.
- Teacher-controlled learning to teacher-learner partnership.
- Teacher-centered learning to student-centered learning.
- Time, age, and group constraints to individualized learning.
- Materials-based organization to needs-based activity.
- Product-centered to process-centered.
- Elective area of study to a core subject.
- Social irrelevance to socially contextualized.

Within the context of these trends, there is also a great degree of diversity throughout the world in technology education (Williams, 1996b). This diversity ranges from the absence of technology education in Japan (Elliot, 1990) to its compulsory study by all students in Israel (Israel Ministry of Education, Culture and Sport, 1996), an instrumentalist approach in Finland (Kananoja, 1996) to a basically humanistic approach in Scotland (Birnie & Dewhurst, 1993), a focus on content in the United States to a focus on the process in the United Kingdom, an economic rationalist philosophy in Botswana

Table 1. Comparison of the World's Population in Terms of Availability of Computers and Phone Lines

Category of Country	% of World Population	PC's/1000	PL's/1000
Low Income	40%	4	27
High Income	14.9%	346	583

Source: (World Bank, 2000).

(Molwane, 1993) and China (Wu, 1991) to a more liberal philosophy of science-technology-society in the United States (Layton, 1988), a staged and well-supported implementation of change as proposed in South Africa (Ankiewicz, 1993) to a rushed and largely unsuccessful implementation in England (McCormick, 1993), integrated with other subjects such as science in Israel, or as a discrete subject in Australia (Williams, 1996a).

Both the commonalities and the diversity are appropriate. The type of technology education developed within a country must be designed to serve that country's needs and build upon the unique history of technical education, resulting in a unique technology education program. This uniqueness challenges some of the notions related to the internationalization of the curriculum, particularly in the area of technology education. Other more traditional disciplines have developed an internationally acceptable body of knowledge, but technology has not and probably never will because of its variable historical significance and the diverse needs of different cultures.

Forms of Distance Education

A typical definition of distance education is the delivery of instruction in a format that separates the teacher and learner, often both in time and space (Keegan, 1980). It tends to be an umbrella term that may encompass more specific forms of education such as distributed learning, independent study, correspondence education, satellite education, etc. The focus of this discussion is text-based distance education, supplemented by intensive face-to-face sessions.

The factors contributing to good quality education are considered to be the same regardless of the mode of delivery, the country, or the

setting. This is because of the "no significant difference" phenomenon associated with distance education research (Frost, 1998). The key variables are the quality of content and the support provided for the students, not the technology (Eastmond, 2000). "People learn as well from traditional print based correspondence courses as they do from the most slickly produced and/or interactive telecourses" (Russell, 1997, p. 6). If not designed and delivered well, distance education, of whatever mode, will only exacerbate poor quality instruction and compound already existing educational problems.

It is difficult to find current research about print-based distance technology education, this having been overtaken by online and Internet modes of delivery. Of the 558 articles on technology education referenced by this researcher, and the 526 full-text online journals accessed through WilsonWeb, a number of searches revealed no research since 1990 on print-based distance technology education.

A comparison of this research emphasis on electronic forms of distance education with the state of the world's population in terms of computer availability, phone lines, and arguably that portion of the population in most need of education indicates a significant imbalance (see Table 1). In low-income countries (40% of the world's population) there is one computer for every 250 people; in high-income countries (14.9% of the population and generally the origin of online distance education) there is one computer for every three people. In low-income countries there is one telephone line for every 37 people; in high-income countries there is one for every two people. There are about 400 million computers in the world, and 300 million of them are owned by 15% of the world's population.

The United States and the former Soviet Union have 15% of the world's population but operate 50% of the geostationary satellites (World Bank, 2000).

It would seem plausible to conclude that the current direction of distance education research is not serving the interests of the majority of the population who need an education and are typically undereducated. This is compounded by the high proportion of untrained and unqualified teachers in low-income countries (Nielsen, 1997) and reinforced by the evaluation of distance education reported in this article.

Course Design

A teacher education course in technology education derives its content from three main sources. One is the educational system for which the teachers are being trained. Information from this source includes syllabi, methodologies, school contexts, etc. The second source is the technological activity that takes place in society, and the third source is from the discipline that is being studied, in this case technology education. The research and literature of the discipline gives guidance on content, structure, learning patterns, and methodologies.

All these systems are vital sources for the design of a teacher-training course in technology education. Graduates need to be suited to the system in which they are going to work, but their tertiary studies should be more than a repetition of the respective secondary syllabus at a deeper level.

Each course reported in this article was designed to accommodate the above characteristics in the context of the appropriate education system. This meant significant local input with regard to the local educational system and the social/technological context. It was found that it is difficult to do this at a distance and requires face-to-face negotiation. The core content and instructional methods were derived from existing units of study, which were then customized and contextualized to suit the specific environment. The background and learning styles of the students are also important to consider, and to some extent knowledge in this area develops as the course proceeds. This revision and sensitiza-

tion process has been repeated each time the course has been offered, as it is not possible to internationalize a technology education curriculum to the extent that it is generalizable and relevant regardless of the country of implementation.

A guiding principle of the course is that students must learn how to learn. With technology changing as rapidly as it is currently, there is a limited life span in the skills students are now taught. Students must be taught how to independently develop new skills and how to find out about new materials, equipment, and systems. Then when the need later arises for personal professional development or for school development, teachers are well equipped for the task.

The contextual goal of the courses is also sustainable development within the country. This applies to individual teachers who, as a result of courses of study, will:

- develop relevant and current content knowledge in technology education;
- incorporate contemporary pedagogical skills into their teaching;
- be better equipped to guide the development of young students; and
- understand international best practice in technology curriculum development.

Typically, courses had to be designed quickly. The identification of a market opportunity was followed by the development and submission of a proposal to the key people in the market. A lengthy delay at this stage could have resulted in missed opportunities. The initial proposal was clearly identified as a flexible starting point for discussion and negotiation about the structure and content of the course, and then after a series of discussions and meetings, the specifics were modified and developed later.

Initial proposals were not specifically costed, but a range of delivery options were outlined, with an indication of the relative expense of each option. Sponsors do not necessarily choose the least financially expensive option, as other factors such as ease of administration and perceived quality of delivery are important factors. In one country the most expensive

delivery option was selected because that was the traditional approach to upgrading teachers in that country.

If the market opportunity was identified by a person not connected with the coordination or delivery of the course, then it was found necessary for a person expert in the content of the course to visit the sponsors to negotiate the course details, answer questions, and develop an understanding of the environment in which the course would be delivered. Important information related to facilities and equipment, prior experience and education of the potential students, curriculum, cultural and regional considerations, and local coordinators.

As a result of these initial visits and communication, a specific and costed proposal and course design was developed and signed by the appropriate parties. Responsibilities of all involved were specifically detailed. This detail is essential and can significantly impact on course success. For example, in one course student consumables were the responsibility of the local sponsors. This proved to be a greater expense than was anticipated and would have impacted significantly on university revenues.

Course Delivery and Structure

The Design and Technology Bachelor of Education (Secondary) program is designed to prepare students to teach design and technology at all levels in the secondary school. The award is granted after the successful completion of four years of full-time study (or equivalent), that is 8 semesters at 4 units each semester, or 32 units. The remainder of the suite of undergraduate courses available in this area of D&T include a three-year Bachelor of Arts degree, a two-year Bachelor of Education upgrade for diploma holders, and a one-year Bachelor of Education upgrade for Bachelor of Arts degree holders. These are all subsets of the 32 units of the Bachelor of Education, which provides a pool of units from which to select the most appropriate for the specific market. So for example, the 16 units of a two-year Bachelor of Education upgrade offered in one country may be different from that offered in another because they are selected and matched to the specific needs of the market.

The courses are delivered through a combination of distance mode and intensive workshops/lectures over a period of up to four years. Students study part time, and enroll in two units per semester. The part-time study involves readings, assignments, assessment, and examinations being forwarded to the students in concert with a period of intensive lectures/workshops in their country. This provides about 30 hours of face-to-face interaction with the lecturer for each unit and is delivered in about the middle of each semester during the school holidays. So students do some study both before and after the on-site classes.

The advantages of this mode of delivery include:

- no disruption to schools through the absence of teachers;
- education activities, discussions, and applications can be grounded in current practice; and
- the opportunity for collaborative teaching and research between local staff and university lecturers.

The upgrade course consists of three types of units:

- Education Studies: studies in the theory of education, educational psychology, and teaching studies and practice.
- Curriculum Studies: studies of relevant curriculum resources and related teaching.
- Content Studies: appropriate specialization content.

The balance of these units varies depending on the local context and needs.

Some courses were proposed as a joint venture between the university and the local ministry of education (in the case of a sponsored cohort of students), with the provision of concurrent opportunities for postgraduate study (MEd or PhD) for local lecturers. This postgraduate study can be done by distance, and opportunities for supervision and guidance would arise through the undergraduate course activities. In some instances a fees-only postgraduate study scholarship for the top academic student has been provided upon completion of the course. Other courses were advertised and

offered to teachers who then are responsible for their own fees.

Costs and Responsibilities

Generally, distance education incurs lower costs per student than traditional face-to-face education, often generated through economies of scale, but this is offset by large dropout and repetition rates. The UK Open University has a completion rate of 49% (200,000 students), 28% at the Indira Gandhi National Open University (431,000 students), and 10% at the Korean National Open University. Completion rates tend to be lower in less-developed countries as students in those contexts typically enroll in distance programs as a matter of necessity rather than from choice (Latchem, Abdullah, & Xinhfu, 1999). The completion rates for the courses described in this article vary from 90% to 100%.

For a specific program offered to a foreign government by a university, the criteria which form the basis of value-for-money decisions include the reputation of the university, the level of understanding of the delivery context, the flexibility of both content and mode of delivery options, fees, and politics.

In this situation the sponsor's responsibilities may include:

- nomination and resourcing of a locally based program coordinator;
- recruitment of the cohort of teachers into the program;
- the provision of an appropriate venue for the on-site teaching;
- funding time off for course participants, for example, one day/fortnight during semesters;
- the provision of consumables and technical support for the on-site teaching;
- organization and funding of mentors; and
- organization and invigilation of examinations.

The university's responsibilities may include:

- all costs associated with university or local staff conducting the in-country teaching;
- provision of all distance education

materials;

- implementing enrollment and recording procedures;
- reasonable remediation of failing students;
- setting and marking assignments and examinations; and
- granting the relevant degree.

If the government sponsors the program, it is funded on the basis of a specific number of students being the minimum in the cohort. If the number of students drops below that level, the cost will be maintained. It is generally agreed that a specific number of students above that level can be enrolled for no extra cost. When individual students are paying their own fees, the university applies a formula of income and costs to determine course viability.

Issues

The following are some of the issues that have arisen from the delivery of distance technology education to technology teachers and the evaluation of those programs.

Level of Technology

Technology education in teacher training serves the dual role of modeling experiences and activities that teachers can implement in their schools when they begin teaching and experiences that enhance their understanding of technology. Both are important because teachers need starting points for their teaching, but also need a sophisticated awareness of the nature of technology. In extending educational experiences across cultures, the correct balance, and the justification of the balance between these two goals, is imperative. In-country experts and the students themselves can provide guidance on achieving this balance. The principles of appropriate technology become relevant in the selection of technological activities and the context of application of the processes of technology education.

In relationship to the mode of delivery, the instructional technology seems not to be a key variable for success. As Frost (1998) has pointed out, any socially just delivery system must ensure that we are not just servicing a small group of well-off elites. New and advanced

technologies will expose traditional cultures to Western values and may create as many problems as it solves. Resulting unrealistic learning behaviors may cause distance education to be viewed as a cultural Trojan horse (Wennersten, 1997). So the level of technology must be at the same time socially equitable, challenging to the participants, and accessible.

Local Capacity Building

There is the recognition that as a result of each course, apart from having better qualified graduates, more local capacity to deliver the course in the future should be developed. The experience has been that unless such capacity building is detailed in the initial contract, it is very difficult to develop during the project. People are very busy, and unless there is some compulsion to undertake additional tasks, despite any long-term advantage that may accrue, opportunities will not be taken up.

The type of collaboration necessary to achieve this end brings with it a number of dangers. One is the danger of cultural imperialism, which is difficult to resist when the visiting lecturers are presented as the international experts. The other danger is the “trendy” aspect of collaboration. “Too often alliances are cobbled together for the purposes of proposal submission. Alliances without ‘roots,’ without an investment in partnership development, will limit the potential for success of projects” (Gerhard, 1997, p. 3).

Facilities

In some countries the facilities are not available to offer units that would normally be considered core units. For example, in technology education these could relate to computer-assisted drawing and machining, advanced materials, electronics, and a range of computer-based units. In some countries these units cannot be offered; in others the unit content can be modified to enable it to be offered in an appropriately contextualized way, for example, with the use of share-ware software rather than expensive commercially produced packages or with local experts discussing local technologies.

Local Politics

There is invariably a political dimension

involved in the context in which the course is delivered. A local course coordinator is invaluable in steering through the potential pitfalls of teaching site selection and dealing with local institutions and authorities, which may respond to a variety of agendas. This can nevertheless be a source of frustration as the sense of urgency felt at the source institution about material availability, for example, is not always replicated in going through the protocols in the local delivery context.

Lecturers

It takes some time interacting with a class for a lecturer to develop a rapport with students, and when they spend 30 hours together over one or two weeks, the relationship seems to become quite strong. Students do not want to go through this “getting to know the lecturer” period with a new lecturer for every unit. However, if the “expert” in each unit is the person sent to do the teaching, then many different people are involved in a course. It has been necessary at times to restrict the number of people involved in course delivery in order to help ensure student comfort.

In instances where it is appropriate to localize course material, a local expert may be involved in presenting to the students. This can, however, be perceived negatively by the students, who consider they are paying for an overseas course and that is what they want, not local lecturers.

Currency

Currency restrictions may inhibit the ability of students to purchase course material. This can occur at both personal and national levels if there is close monitoring of the country’s foreign currency reserves. This has been overcome at times by selling resources in local currency to the students and then using that income for local expenses of the project, but still may result in curtailing the resources available to students.

Course Duration

Some of the students have been dissatisfied with the duration of their course. They would have preferred, for example, to study for three semesters per year and complete a two-year full-time course in under three years part time than

to study for two semesters each year over four years. This more intensive mode of delivery places increased pressure on the source institution and may result in negative consequences on other aspects of departmental activity.

Communication

Because standard means of communication such as mail, Internet, and fax can be unreliable or nonexistent, communication with both students and coordinators in the host country can be frustrating. Typically, some students have Internet connections, and mail and fax are unreliable. This means forward planning is critical, and normal processes may sometimes need to be circumvented. For example, an unreliable mail system resulted in a batch of exam papers going missing and alternative strategies had to be devised; and assignments, both to and from students, are express mailed together to a central location rather than to individual students.

Conclusion

For many students, text-based distance education represents their only source of educational opportunity. In the area of technology education, a successful mode of delivery incorporates a period of intensive face-to-face interaction with a lecturer. Detailed planning and the contextualization of both content and methodology is vital, but flexibility in the implementation of those plans is just as important in order to overcome unforeseen barriers. Key variables for success include high-quality content, appropriate methods, and student support to enable them to effectively utilize new knowledge.

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Databases Improve Technical Studies

By Gabriele Graube

35

Target

In Lower Saxony, technology studies as part of preparing technical education teachers for primary and partly for secondary education can be studied only at two universities—the Technical University of Brunswick and the University of Oldenburg. Technology education is not available at the Gymnasium (a type of secondary school leading to the university) in Lower Saxony.

Universities in Lower Saxony and other German states have agreed about the basic contents of technology education that should be taught in the public schools. However, the themes are emphasized differently, because the universities view the subject and conduct their research differently from one another.

The target is to connect the technical resources of the participant universities to reveal the variety of contents of the subject and to allow access to sources of knowledge irrespective of time and place. Specifically, the creation of accessible databases for technology education via the Internet will help educators teach technology as thoroughly as possible and offer the opportunity to reach larger numbers of students at colleges and universities. A further step will be to connect the databases of individual partner universities to a database network.

The technology education database is meant to represent an important scientific and didactic source for the subject *technology*. Our further intention is to include the latest results of research, including that gained from national and international technical learning processes, and to maintain teachers' educational experiences in the form of evaluated teaching samples. We plan to include proven samples of lessons that have been tested by teachers, lecturers, and students as "methodical patterns" that can be used subsequently by other students and lecturers.

The technology education database will help students to fulfill the following tasks during their studies (Dick, 2000; Scheuermann, Schwab, & Augenstein 1998):

- Acquire and select specific information for special themes.

- Prepare papers and work on scientific reports.
- Prepare and rework lectures.
- Study the contents of technology education irrespective of the place of studies and the type of school.
- Study as independently as possible.

Lecturers will get support to fulfill their educational tasks:

- Compile and work with technical literature.
- Select adequate educational material, either discrete (texts, pictures) or continuous (video, audio, simulations, animations).

Advantages of the Technology Education Database

The technology education database has several advantages. It will:

- Create a source of knowledge concerning technology education at universities and public schools.
- Ensure efficient presentation of the interdisciplinary structure and the variety of contents of the subject and its various media and methods.
- Have flexible application of the database's modules (applicable in a new context, adjustment of contents, application regardless of time).
- Allow students and lecturers to have access to the database via the Internet irrespective of time and place to plan studies independently or to prepare lectures.
- Enable national and international exchange of knowledge and experience between universities.
- Promote self-learning.
- Develop competence with regard to media and information.
- Awaken the interest of females in technology education by offering easy access to knowledge.
- Enable worldwide distribution of educational material.
- Facilitate students' transfers between institutions not only within one federal state but all over Germany, as certificates

are mutually accepted.

- Facilitate installation of a course of study for Europe or overseas (medium-term and long-term plans).

Contents of the Technology Education Database

The contents of the technology education database are closely related to the courses of study of the university. Although courses of study differ from university to university, the fields of study are identical in most cases. The content of the fields of study is focused on technological processes and systems that are categorized by material, energy, and information.

The courses of study include not only special scientific fields, but also special didactic fields that students must study. Usually the contents are taught in the form of lectures, seminars, exercises, and practical training in laboratories and workshops. As a target of the database network, the fields of study will be enhanced by the multimedia teaching and learning modules of the technology education database.

If it is possible to update lectures and to give them a personal note, then the content will have to be split into modules. The modules can then be used in different types of lectures and can be combined and completed in such a way that they meet the requirements of the individual courses of study.

The fields of study for the database must be selected. The modules have to be of special importance for the studies and, therefore, for the future professional work of a technology teacher. Thus, the modules to be developed should have a key function and students must master them through examinations.

In the first phase of this database network development, the University of Essen and the Universities of Brunswick and Oldenburg will create databases in their special fields. The Institute for Technology and Technical Didactics of the University of Essen plans to create modules for the following fields of study: materials science, energy technology, measurement, open-loop control, closed-loop control, and environment protection. The Department of Technology Pedagogics of the Technical University of Brunswick and the Institute for Technology Education of the University of Oldenburg intend

to create modules for the following fields of study: manufacturing engineering, information and communication technology, and didactics of the subject technology.

In Essen as well as in Brunswick the first modules and experiences already exist. The Institute for Technology and Technical Didactics of the University of Essen has created the first modules during a project, Component-Based Learning Software for the Training of Teachers, sponsored by the federal state of Nordrhein-Westfalen (<http://it.tud.uni-essen.de>). During the summer semester 2000, the Department of Technology Pedagogics of the University of Brunswick tested the application of an Internet module, Creation and Application of Websites for Learning Processes.

The modules may include exercises, examples of lectures, complete training programs, and single components. They are categorized and stored according to criteria that are important to the courses of study. Texts, graphics, animations, and videos as well as simulations, virtual tests, virtual laboratories, and case studies will be included in the modules. The possibility of authentically presenting complex technological/scientific matters is a project target that can be reached with the help of multimedia visualization.

One example is an ActiveX-Component, showing the characteristic of a feedback control unit based on an operational amplifier, which serves as a laboratory test. Video clips are intended to be used for the visualization of manufacturing processes to support the practical part of the studies (Schweres, Redeker, Theuerkauf, Balzer, & Rummel 1998). Videos will also be used for case studies that evaluate technology.

The individual databases of the network are being developed so that the contents of each are complementary. This process will take a longer period of time. The databases located at the universities will be dynamic. They require ongoing maintenance to remain current and thus require a new form of cooperation between the partner universities.

Practical Realization

It must be ensured that the database is accessible at any time and from any place. To meet these requirements, the modules and the

components of the database will be accessible via the Internet using Netscape or Internet Explorer. However, a prerequisite for this is that the didactically shaped modules are prepared in such a way to allow Internet capability.

Thus, new and existing knowledge must be structured, shaped, and transformed with respect to the rules of multimedia learning environments. This means that they have to be transformed into Internet formats (HTML, ActiveX, Java, JavaScript, etc.). This requirement is also necessary for the components of the individual modules. Texts must be formatted as xxx.pdf/rtf, graphics/pictures as xxx.jpg/gif/png, and videos as yy.mpg.

All files will be stored with their source code and documentation in databases running on Web servers of the universities.

As an example, the database will be installed on the computing center's dataserver of the Technical University of Brunswick. For this purpose, a determined storage capacity with defined access authority is at the user's disposal.

Learning Arrangement

With the database, lecturers have a source of the most up-to-date scientific and didactic contents including an address collection of Internet sources that enables them to use new methods for teaching. The components and modules can be used by the lecturer to demonstrate technological matters in lectures/exercises/tutorials. The lecturers can organize their courses without restrictions concerning contents and methods. The modules, which are independent concerning the contents and which can be combined variably, represent a source of information for courses, exercises, and projects.

However, technological processes, systems, and virtual laboratories can be visualized more authentically with simulations than with conventional media (Fäßler, 2000). Knowledge about the relationship of technological processes and systems can be obtained with the help of simulations.

With the database's contents structured according to didactical aspects, students can acquire information for a chosen or given theme for an exercise, a laboratory test, a task, or a project. As an example, components of the database can be included in one's own work.

The acquisition and evaluation of information will get more and more important, particularly regarding technical competence.

The database supports independent study, so that the themes of the courses can be expanded and completed. At the same time, students achieve media competence with respect to selection and evaluation of information as well as with the creation of new or improved modules during seminars or exams. Afterwards, these modules can be stored into the database, too. A module that helps to create Web sites will be the basis to transform teaching and learning methods so that it can be used on the Internet.

Partners of the Database Network

Internet-based studies and further education courses already exist on national and international levels. Designing the database without restrictions calls upon us to use experiences and developments of the special fields of other universities that are involved in the courses of study for technology educators and that also use multimedia in teaching.

Partners for this project among the federal states of Germany are the Department of Technology Pedagogics of the Institute for Scientific Didactics of the Technical University of Brunswick and the Institute for Technology Education of the University of Oldenburg. Other partners of the database network are the Institute for Technology and Technical Didactics of the University of Essen and the Institute for Technology and their Didactics of the University of Dortmund, which is responsible for the subject technology in secondary schools. The Institute for Vocational Education of the University of Rostock, which trains teachers for electrical engineering at vocational colleges, has announced its partnership, too. These partners ensure that in Germany the different courses of study for technology education in primary and secondary schools and in vocational schools are represented appropriately.

Due to the international interest in an exchange of training modules, a continuation project to enlarge the database network will follow in cooperation with partners, such as the University of Marseille, the University of London, and the Chilean Ministry of Culture. This database network can be seen as an important global source and as a forum for technology education. This step seems to be reasonable to

internationalize the course of studies for technology education as it exists in other nations, too.

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Strategies for Reforming Workforce Preparation Programs in Europe

By Marja-Leena Stenström and Johanna Lasonen

The SPES-NET Project

The Post-16 Strategies project coordinated by Dr. Johanna Lasonen from 1996 to 1998 was chiefly concerned with four post-16 education strategies: *vocational enhancement*, *mutual enrichment*, *linkages*, and *unification*. These four strategies to promote parity of esteem between vocational and academic/general education were also seen as tools for analyzing the differences and similarities between the reform approaches adopted in the eight European countries (Austria, England, Finland, France, Germany, Norway, Scotland, and Sweden) associated with the first project (Lasonen, 1996, 1999).

The strategy of *vocational enhancement* entails reforming the content of vocational education and training separately from general/academic education. Esteem for vocational education is assumed to be linked with the standard of the content offered and the pedagogy applied in vocational education and training.

In the strategy of *mutual enrichment*, the aim is to cooperate across the divide between general and vocational education and to give students in each track a wider range of options by drawing on the best features of the other track. The two types of education are brought closer to each other but retain their distinctive character.

In the *linkages* strategy, vocational and general/academic education are given the same formal status and linked through a common certification framework. Both types of education guarantee qualification for further and higher education, and earlier studies are recognized irrespective of track.

In *unification*, the distinction between vocational and general education is abolished by combining them within a unified system and developing a curriculum that integrates the two types of education.

The first three strategies aim to maintain a separate identity for vocational and general education. By contrast, the fourth strategy seeks to combine them into a uniform upper secondary education system (Lasonen, 1999).

SPES-NET (Sharpening Post-16 Education Strategies by Horizontal and Vertical Networking) known as the Leonardo da Vinci project, continued the work of the Post-16 Strategies project. Lasonen also launched and Stenström coordinated the SPES-NET project that was funded by the European Commission, the Finnish Ministry of Education, and the proj-

ect partners, and that ran from 1997 to 2000.

It focused on reanalyzing and exploiting the four hypothetically identified reform strategies intended to promote parity of esteem between general and vocational education in upper secondary education.

Aims of the Project

The SPES-NET project focused on promoting vocational education and training in the partner countries, which increased from the original eight countries in the first project to 13 nations in this project. An initial objective of the Post-16 Strategies project was to find ways of improving the status and attractiveness of vocational education and training.

The aims of the succeeding project, SPES-NET, were to:

- Find ways to improve the status of vocational education and training.
- Find ways to forge links between educational establishments and enterprises.
- Disseminate the results of the Post-16 Strategies project.
- Define dissemination activities intended to create national and international networks.

Table 1. Partner Institutions: Type of Institution

Type of Institution	New Partners	Old Partners
Research institute		England France Austria
University department	Spain Greece Hungary	Germany
Further education college		Scotland
Teacher training establishment	Denmark	Norway
Administrative agency	Estonia	Finland
Consultancy and training establishment	Belgium	

Since the partnership had been extended to southern and eastern Europe, it became possible to evaluate the four previously identified post-16 education strategies in a new context. The project also tried to find ways to develop links between education and work as an important method for improving the status of vocational education.

The Partnership

The partnership brought together 14 institutions from 13 European countries including the new partners from eastern and southern Europe (see Table 1). Some partners represented researchers and others the context of practitioners. The SPES-NET project was carried out by a multicultural team representing researchers,

policymakers, administrators, and teacher educators. The methods used were calculated to promote mutual understanding and shared solutions while also producing cross-national knowledge of ways to improve the quality of initial vocational education. The workshops featured presentations of data and syntheses, roundtable discussions, and brainstorming sessions. Conclusions pertaining to separate nations were drawn as were comparisons. The results of the comparisons were disseminated in each partner country (Stenström & Lasonen, 2000).

The range of different backgrounds of the representatives made for a fruitful environment for a dissemination project. The interdisciplinary nature of the project was considered a

Table 2. Educational Reform Strategies

Strategies by countries Substrategies	1. Vocational enhancement Germany Austria Denmark*	2. Mutual enrichment Finland Norway	3. Linkages England France Spain*	4. Unification Scotland Sweden
1. Improving links with higher education (HE)	Reforming and expanding vocational HE	(i) Improving access to existing HE (ii) Creating a new vocational HE system		Creating a single system of post-compulsory education
2. Improving links with employers	Strengthening dual-system partnerships	Strengthening partnerships between providers of VET and employers		Strengthening links between employers and vocational and general education teachers
3. Raising the status and qualifications of vocational teachers and trainers	Equalizing the status of vocational and general education teachers	Providing some common courses for vocational and general education teachers		Common training and qualifications for general education and vocational teachers
4. Improving the VET curriculum	Improving the vocational education component	More general education on vocational programs		More integrated learning

*New partner

Sources: Lasonen, 1996; Young, 2000.

positive feature because it created bridges to shared understanding between different countries in Europe. This multidisciplinary, multicultural approach produced a range of different solutions to the problems of vocational education and training (Lasonen, 1998; Stenström, 2000).

The SPES-NET project undertook a reanalysis of the previously identified reform strategies, proceeding through the following stages:

1. Analyzing the four post-16 education strategies in a new context.
 - Preparing and analyzing case studies of the new partner countries.
2. Reflecting on the post-16 education strategies.
 - Fitting the new partner countries' reforms into the framework of the four post-16 education strategies.
3. Developing a framework paper on new substrategies for the previously defined four post-16 education strategies.
 - Preparing a final summary of the sub-strategies on the basis of the partners' responses to an earlier draft of the framework paper, which was prepared by the English partner (Young, 2000).
4. Surveying the progress of forming links between educational establishments and enterprises.
 - Preparing a framework paper on education-work relationships (Marhuenda, 2000).
 - Case studies of the partner countries.

Reflections on Post-16 Education Strategies

It was not easy to classify educational systems in terms of the four post-16 education strategies. The four hypothetical reform strategies of the Post-16 Strategies project revealed that contexts existing in northern, western, and central European countries made the comparisons complicated. Extending this analysis to other regions was particularly difficult in the case of countries undergoing structural and political changes, such as Estonia and Hungary, and in the case of countries such as Estonia and Greece, where vocational secondary education is not well developed (Stenström, 1999).

The question the SPES-NET project faced was whether the previously defined four post-16 education strategies were relevant to the new partners or whether a model that included a strategy for academic track separate from vocational and a strategy where they are unified should be adopted instead. However, it was decided to retain the original typology but shift the focus of the comparisons to improvements in the quality of vocational education. Out of the larger context provided by the 13 European partners a new conceptual framework of strategies and trends emerged. It was clear that reform strategies must be defined in a more precise manner, distinguishing between the different substrategies for improving vocational education and its status relative to general education as follows (Stenström & Lasonen, 2000; Young, 2000):

- Improving progression to higher education by students in vocational programs.
- Improving progression into employment by students in vocational programs.
- Improving the status and qualifications of vocational teachers.
- Improving the vocational and general components of the vocational education curriculum.

These substrategies were used for comparing reforms launched in different countries to improve vocational education.

In Table 2, the horizontal axis is represented by the four strategies that were identified in the original Post-16 Strategies project. The vertical axis is the four substrategies for improving vocational education that were identified in the SPES-NET project. The matrix shows the relation between strategy (as context) and substrategy (as content). The partly hypothetical options presented in the matrix indicate the existence of three types of reform strategy because the matrix combines two of the previously defined four strategies, mutual enrichment and linkages.

All partner countries had reported some developments definable in terms of the four substrategies. The substrategy of improving progression opportunities into higher education for vocational education students seems to be the easiest one to adopt. The substrategy of improving the status and qualifications of vocational

teachers is difficult, especially in those countries in which salary differentials between private and public sectors remain large. Finally, improving the vocational curriculum depends on administration, teaching, and teacher education and on cooperative links between employers and vocational education providers. The relationships between education and working life is one of the key questions involved in attempts to improve the quality of vocational education and training.

The SPES-NET project *focused* exclusively on *internal strategies* for improving vocational education and training, ignoring external strategies. Such external strategies as interventions in labor markets might affect the status of vocational education and training and the issue of parity of esteem.

The SPES-NET project also *concentrated* on differences between national systems and national strategies for improving the quality of vocational education and parity of esteem between vocational and general education as they are manifested *at the policy level*. It was not concerned with new curricula and pedagogies. However, moving from the level of strategy to the level of specific curriculum and pedagogic initiatives would be a valuable topic for further research (Young & Volanen, 2000).

The partner countries face a number of common problems despite having very different educational systems. These common issues relate to ways in which attempts to improve vocational education continue to be hampered

by the persistence of academic/vocational divisions in the curriculum. First, there is academic drift or the tendency to encourage students to opt for academic programs. Second, there is the concern expressed by both employers and vocational teachers about the poor quality and lack of motivation of students in vocational programs. Third, academic/vocational divisions are inhibiting the development of new types of vocational programs for the 21st century.

Despite the differences in how the sub-strategies are interpreted in different countries, some common trans-European trends did emerge. These are summarized as:

- More standardization of qualifications for students and teachers.
- Greater emphasis on work-based learning and the educational potential of work-places.
- Efforts to increase employer involvement in all aspects of vocational education and training provision.
- More choices for students and more autonomy to localities and individual institutions.

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Relation of Technology, Science, Self-Concept, Interest, and Gender

By Ingeborg Wender

The Need for Promotion of Women in Science and Technology

For nearly 20 years the topic of “women and technology” has played an important role in discussions about gender equality in Germany. The very first project for promoting females started in 1978 under the title “Women in Male Occupations.” It was initiated by the Federal Ministry of Education and Science and was aimed at vocational-technical levels. Soon a

variety of projects followed, financially supported by the Federal and District Commission for Educational Planning and Promotion of Research and by the individual governments of the various districts (Ostendorf, 1994).

The initial incentive to develop such projects was the fact that women were highly under-represented in educational fields of technology and in those related to technology. Increasing

the number of women in technology and science was a political goal. Consequently, many actions were initiated to increase women's participation in schools, universities, and/or extracurricular fields. Currently, special attention is being paid to specific subjects such as computer science and computer technology. The reason for this is the current lack of experts in these fields.

Despite the important role of technology in society, it is seldom taught in schools. That was not the case in the former Federal Republic of Germany. A special polytechnical teaching existed in schools; unfortunately, it was given up after the reunion. Therefore, we have an obvious deficit in Germany.

Because the proportion of students in natural, computer, and technological sciences has sunk dramatically in general, there are now various educational programs to increase the attractiveness of these subject areas. Most prominently, colleges and research institutions advertise intensively and offer their research resources to teachers and pupils. The best examples are the Göttinger Experimental Laboratory for young people (XLAB of the University of Göttingen), which concentrates on natural science, and the DLRSchoolLab of the German Center for Aeronautics and Space Travel in Göttingen, where aerodynamics is stressed. Almost all technical colleges offer pupils a day or a week of open house, including experiments and special projects. Pupils aged 15 to 20 are the main target group of these activities.

Because of the well-institutionalized promotion of women at colleges, a diverse science and technology campaign was developed, which has acted as a forerunner for current activities (such as our own projects Hands-On Technology [1993-1999] and Step In—Mentoring & Mobility [2001-2003], which will be described later). Computer science was and is generally an integral component in the projects. However, there is a difference between computer science as an independent subject and its application in a technical discipline. Concepts have been developed for both aspects. Activities for the promotion of women in Germany are currently somewhat one-sided with the emphasis on computer science.

Little Increase in Female Proportions in Technology and Science

In spite of these promotional efforts, the proportion of females in those “hard” courses in natural and computational sciences and in fields of technical studies and occupations remains small, though 45% of all students are female and 50% of the students in university beginning studies are female. Over the last decade the activities to encourage women have only slightly increased their percentages in the above-mentioned fields. The rate of female students increased in electrical engineering from 4.4% in 1992 to 8.6% in 2001, in mechanical engineering from 5.3% in 1992 to 10% in 2001, and in computer science from 13% in 1992 to 19% in 2001 (Federal Ministry of Education and Research, 1993–2002). The increase in women, even if small, may be explained by the efforts in the context of promotion activities for women, that is, the projects have been nevertheless successful.

Consequences

The above-mentioned increases in women's participation need to continue at a greater pace. This could happen if the projects could take long-term perspectives into account and not merely exist at brief intervals. Those who engage in promotional efforts, and all educators, for that matter, need to be aware of several other factors that may affect women's interest and participation in the technology fields.

Self-Concept (Self-Efficacy Belief), Gender, and Technology

Self-concept gained scientific attention for explaining the exclusion of women from technological fields, particularly young women's lack of confidence in their own efficacy to handle technical situations adequately.

The concept of self-efficacy (Bandura, 1997) has gained popularity in recent years, especially in educational and vocational issues. When choosing a career, perceived self-efficacy has long-term consequences. People with high self-efficacy expectations consider a wider spectrum of possibilities to develop themselves in relation to specific subjects and vocations and hold higher aspirations. For example, when choosing a career in mathematical/technical

fields, high perceived self-efficacy bears more relevance than actual quantitative and technical competence (measured according to education and capabilities; Hackett & Betz, 1989). Subjective self-efficacy judgments are one of the most relevant determiners of success and persistence in a career.

Perceived self-efficacy refers to the beliefs in one's personal capabilities to organize and execute the courses of action required to manage prospective situations (Bandura, 1997). Self-efficacy produces effects in various ways, including mainly cognitive, motivational, affective, and selection processes.

People who have a low sense of efficacy in a given domain

- shy away from difficult tasks,
- have low aspirations and a weak commitment to goals,
- slacken their efforts and give up quickly in the face of difficulties, and
- diagnose insufficient performance as deficient aptitude and lose faith in their capabilities.

Self-efficacy beliefs are products of complex processes of self-persuasion. These processes rely on the cognitive "working up" of diverse efficacy information.

Bandura (1997) designated four sources of self-efficacy that can help to dispel doubts concerning one's own self-efficacy perceptions. These sources may enable persons to deal effectively with certain situations, each including

- mastery experiences, an enactive factor;
- vicarious experiences, influenced by perceived similarities to role models, observed;
- coping processes and participant and corrective modeling;
- encouragement from one's environment (e.g., social and/or verbal persuasion); and
- positive interpretations of one's physiological and emotional states.

Women generally judge themselves as being less efficacious than men for scientific occupations requiring quantitative skills, such as engineering and computing (typical male

vocations where the percentage of women is equal or less than 25%), whereas men judge themselves less efficacious than women for education and psychology (typical female occupations where the percentage of men is equal or less than 25%; Wender, 1999).

Hackett (1995) provided empirical data that supports the theory that the low proportion of women in technical vocations can be traced back to women's low perceived self-efficacy regarding technical problem-solving skills.

Because gender groups experience socialization differently, girls and young women find it difficult to attain technical information and experience, and when they do, they cannot adequately process it. Women are hindered in building up and enlarging high self-efficacy expectancy for the technical and engineering fields. This is connected to a high degree of gender and social role model stereotyping.

A stereotype is a set of qualities ascribed to all members of a group of people or objects because of overgeneralization. Alfermann (1996) pointed out that women are perceived as preferring social relationships. For example, a woman is regarded and regards herself as preferring social relationships. Social roles are distinguished through behavioral expectations that society assigns as norms to members of a certain group. According to Alfermann, even today it is still usual that women take care of children and stay at home after the birth of a child and men do industrial work.

In accordance with the stereotype that describes women as incompetent in natural science and technology, girls often underestimate their own performance in mathematics and natural sciences. The TIMMS studies confirmed gender differences regarding confidence in one's own capabilities in these subjects and concluded that even very capable, highly successful female students tend to underestimate their own capabilities and assign success more to luck or accident (Baumert, Bos, & Lehmann, 1997).

Gender stereotypes and gender role expectations also influence expectations of different agents of socialization. Parents, teachers at

schools and universities, and instructors in business develop expectations of their children, their students, and their trainees. Thus, a sort of self-fulfilling prophecy sets in and all involved base their behavior and experience on expectations set up by social groups. Even persons being educated follow these expectations, be they positive or—as concerning girls in relation to technology—negative for themselves.

The Function of Interests

According to Hannover (1998, in press), self-concepts are closely related to interests, and these, in turn, are closely related to vocational decisions. Self-concept influences the development of interests, and interests shape self-concept. Both determine the decision to pursue a subject or a vocation.

Todt and Schreiber (1998) defined interest as follows:

Interests are domain-specific behavior—and experience activating and controlling motives, which are generalized, serving as structures of orientation and appearing in a specific manner as preferences for activities. Interests are essential elements of the structure of self-concept and are fully integrated in the individual's self-concept. (p. 25)

They also differentiated three forms of interest:

- General interests: content and age related, relatively enduring, whereby the influence by concrete experience is rather small, their function exists in orientation.
- Specific interests: relatively enduring, dependent on external hint and on positive experience, related to relatively specific contents or activities and to specific competence, their function exists in initiation activities.
- Active interests: positive emotional state, dependent on specific characteristics of situations, for example, success, positive social-emotional climate, can become dispositional if, for example, stabilized by positive consequences, their function exists in activating cognitive functions and stability activities.

As studies have shown, girls and boys, women and men have differing interests. Women prefer animated content, having something to do with people, having an obvious relationship to everyday life, relating to natural phenomena and of some use to humanity. Men, on the other hand, are less context dependent; they are more readily fascinated by apparatus and machines as such and concentrate on the object at hand (e.g., Häußler & Hoffmann, 1998). These elements can be distinguished as general interests; they are aligned with orientation and hardly available to change by experience. Since they are considered relatively stable, they must be taken into account in developing activities to promote an increased interest of women in technology and natural science.

In contrast, differing interests relating to individual subject areas such as German and physics can be affected by experience because they are specific interests. They can be influenced and affected by active interests. According to Todt and Schreiber's (1998) model, positive feedback, success, and a positive social-emotional climate closely associated with the various subject areas can influence them.

Hannover (1998) established that real life behavior experiences in the particular subject area are especially influential factors. Practical experience gives knowledge about content that is integrated into knowledge structures and anchors the corresponding interests as a personal experience and part of self-applied knowledge. These interests initiate new activities that contribute to the expansion of object-knowledge, of self-knowledge, and of the creation of self-concept. Thus, these components evolve into a circular process.

Hannover (1998) and Hannover and Kessels (2002) support the theory that in coeducational school situations, particularly with exercises that revolve around technology, gender segments of self-concept are activated and control interests in adolescents because of the presence of people of the opposite sex. In school situations where only women are present in a learning group, the gender-related segment becomes relatively inactive, and interests could

develop independently. So if girls' interests should be turned to technology (against the gender stereotype), gender separate teaching is advisable.

These statements are empirically supported by the fact in 1980 young women studying technology or the natural sciences in Germany mainly graduated from girls' schools (Jahnke-Klein, 2001). And as Metz-Göckel (1999) stated, graduates from the women's colleges are very successful both in science and in the labor market.

Encouraging Women Into Technology and Science

Summarizing the preceding paragraphs, one may conclude that young women aged 15 to 20 are encouraged into technology and natural sciences if the following preconditions are taken into account.

- Regarding self-efficacy (Bandura, 1997):
 - Active, physical approach to technical problems.
 - Support from female role models.
 - An atmosphere that encourages confidence.
 - Help to interpret possible tension as positive stress.
- Regarding general aspects of interest (Häußler & Hoffmann, 1998):
 - Inclusion of technical problems in everyday situations or an everyday context.
 - Consideration of relationship with life, particularly with people.
 - References to natural phenomena.
 - Possibility to recognize human or social usefulness of the exercise.
- Regarding the aspect of specific and active interest (Todt & Schreiber, 1998):
 - Active examination of technology.
 - Acquisition of technical knowledge.
 - Creation of a positive social climate.

It should be stressed, though, that knowledge, self-concept (and in particular belief in self-efficacy), interests, and choices/decisions of vocation are closely related and mutually dependent.

In order for girls to avoid activating gender-

related knowledge, a gender separate learning situation should be available (Hannover & Kessels, 2002). This would contribute to building up their perceived self-efficacy and promote development of a young woman's quantitative and technical talents. Future women engineers need to be provided with a learning environment that promotes and supports feminine general interests, giving them the opportunity to develop specific interests for natural science and technology to maximize their potential in these fields. Such schooling would induce girls and young women to gain technical knowledge, make them aware of their own competencies, give them a chance to develop specific interests beyond gender stereotypes, and give them the opportunity to acquire vocational skills in technology and natural science.

Projects of the Universities in Brunswick to Encourage Women

The projects of the universities in Brunswick, Hands-On Technology (1993-1999; Wender, Strohmeier, & Quentmeier, 1997) and Step In—Mentoring & Mobility (2001-2003; Wender, Popoff, Peters, Müller, & Foetzki, 2002), are based on the social-cognitive modification strategies of Bandura (1997) as well as on the previously cited views of Hannover (in press), Häußler and Hoffmann (1998), and Todt and Schreiber (1998) in relation to interests. They combine activity-related measures (e.g., technology days or camps, computer workshops) with a mentoring program for schoolgirls, students, and experts from technology. The Step In—Mentoring & Mobility project concentrated its content on an interdisciplinary subject, that is, mobility/traffic with its technical, social, ecological, and psychological aspects.

The focus of the projects were on

- increasing knowledge of vocations in science and technology,
- increasing perceived self-efficacy of quantitative and technical tasks,
- increasing interest in technical fields, and
- considering occupational possibilities that include technical tasks as the dependent variables.

Several intervention modules were designed

and applied. Established practices used in classes training students for their choice of future occupations were changed or complemented for the purposes of these projects: a three week-period of practical work, courses and vacation camps over several days designed for young women to develop interest in natural and technical sciences and computational science. In order to develop career orientation, a course lasting one week was offered to young women and men. The course included a work company over two days in business for the young women in technical domains and for the young men in social and educational domains.

In order to guarantee long-term promotion for the young women in the project Step In—Mentoring & Mobility, a particular mentoring program was conducted after the end of the vacation camp that offered special coaching for several months. During the camp the girls had the opportunity to write down their wishes for the mentoring program in a questionnaire.

Below follows an example of the practical studies offered yearly between 1993 and 1998 by the Hands-On Technology project. These three-week courses were attended by 120 young women (aged 15 to 20) in the above-mentioned period. The text is taken from an information brochure that advertised these practical studies in schools.

***Institute of Flight Guidance and Control
Technical University of Brunswick/
Germany***

During their practical courses, trainees are involved in the preparation, the carrying out and the evaluation of simulation-and flight-experiments in a flight simulator. Different methods of approach and landing procedures, different turns and wind situations or specific motor flights are being tested and analyzed. These experiments aim at the test of new flight techniques in order to increase security standards in air traffic.

Moreover, trainees will get to know the evaluation of measured atmospheric data, such as pressure, density and temperature or data from real flight experiments such as position, velocity vector or air data.

This includes an introduction to the measuring instruments of our plane at the research airport Braunschweig. Main aim of this survey at our institute are both the development and the test of new measuring techniques.

Instructor: Dipl. Ing. Ronald Blume

The main activity of the Step In—Mentoring & Mobility project is a mobility camp in the summer holidays that was executed in 2001 for the first time and will be repeated in 2003. More than 50 girls participated in the first camp. For one week, girls have the possibility to take an active role in technology by working on two projects each. During the mornings, projects are offered at different technological institutes. These projects mainly deal with actual research in the field of mobility. During the afternoons, the projects concentrate on practical, social, ecological, and psychological aspects of the topic.

Below follows an example of the practical project work offered by Step In—Mentoring & Mobility in the framework of the above-mentioned mobility camp. The text is taken from an information brochure that advertised the camp in schools.

Who likes shaking cars?

How to transfer driving test collected data on vehicle vibration to a hydraulic simulator for a survey on driving comfort

***Institute of Vehicle Engineering, Technical
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The topic of driving comfort plays an important role in the development of cars as it is one of the main qualities in people's judgement of motor cars. Therefore, knowledge of human vibration-perception—how do people perceive and judge different vibrations—is of great importance for automotive industry.

By shifting the analysis of this vibration-perception from the road to a simulator, one not only reduces the amount of expensive driving tests, but also offers additional flexibility to the survey methods.

In this project, you are introduced to the

main tools and processes involved in the transfer of real vehicle movements to a test bench. You may independently equip a car with measuring technique and make measuring drives on the institute's grounds in order to collect data on the vehicle's vibrations. In the end, you transmit these to the institute's simulator.

Instructor: Dipl.-Ing. Thorsten Bitter

The above-mentioned activity-related measures not only offer the possibility to actively approach and experience technology, but, moreover, give the opportunity to form or renew mentoring relationships. Specific mentoring workshops also facilitate an interchange between schoolgirls, students, and experts from technology. These workshops train female experts for their role as mentors and role models, especially by showing their behavior in male-dominated contexts. They also give the opportunity to acquaint key qualifications.

The Step In—Mentoring & Mobility mentoring program was developed especially to consider the needs of schoolgirls. Temporally restricted forms of group mentoring as part of activity-related project measures are of great importance for the mentoring process. Individual contacts between a schoolgirl and several mentors often continue after the group measures are completed.

Evaluation

In order to guarantee a constant improvement of the intervention program, all parts of the projects are being regularly evaluated. Among other things, participating girls have to fill in pre- and post-participation questionnaires, concentrating on knowledge, self-efficacy belief, interests related to technical fields, and the choice of vocation, as well as the expectations and experiences from the different aspects of the project. Moreover, our own observations, audio and video recordings, and posters and reports made by the girls are part of the analysis. Participating tutors and mentors are also questioned in order to modify and constantly improve the programs.

Two examples of the evaluation are described here. The first example relates to the

Hands-On Technology project, concentrating on the three-week period of practical work courses that were offered yearly between 1993 and 1998 and were attended by 120 young women (aged 15 to 20). The second example relates to the Step In—Mentoring & Mobility project and to its main offer, a summer camp, organized for the first time during the summer holidays in 2001. Fifty young women (aged 15 to 20) participated in this camp.

In the Hands-On Technology project the previously mentioned dependent variables were measured for the three focus fields (civil engineering, mechanical engineering, and electrical engineering) in pre- and post-participation questionnaires. The data were collected based on Betz and Hackett's (1981) measurement instrument. The statistical analysis compared the data collection for knowledge, self-efficacy, interests, and possible choice of vocation before and after the intervention of the intervention group (only women) with the control groups (women or men in three week-period of nontechnical practical studies). Follow-up analysis of the data was completed with the help of the Kruskal-Wallis one-way ANOVA (see Wender et al., 1997).

Between the intervention and control groups high significant differences were found with respect to the perceived self-efficacy related to the field of engineering; significant differences appeared with respect to knowledge and to interests; a numerical tendency was found with respect to possible choice of vocation. Most changes in the pre- and post-questionnaires were found in the intervention group.

As one result of Step In—Mentoring & Mobility, data were collected from young women participating in the summer camp. The questionnaires were based on the dependent variables previously mentioned, concentrating on vocations in the domain of traffic. Again, data were collected before and after the intervention.

The statistical analysis was done with the help of the Wilcoxon test. The data showed a significant increase after the intervention on all measured variables (see Wender et al., 2002).

Conclusion About Intervention

It is safe to conclude that the intervention programs were and still are successful. The questionnaires show significant changes regarding the schoolgirls' knowledge, their self-efficacy beliefs, and their interests in technology. Their newly gained and/or more consciously experienced knowledge and interests led to new perspectives concerning the girls' choices of vocations. They now consider more vocations, generally differing from stereotypically female ones. Their possible choices of vocation therefore significantly rose due to their participation in the project.

The mentoring workshops led to significant changes regarding the self-confidence of both

schoolgirls and mentors in male-dominated conflict situations. Moreover, network-building can be noticed among all participating groups.

Therefore, when women are given the opportunity to engage in technical tasks and to succeed—and by doing so not to correspond to traditional gender stereotypes—they are contributing to the decline of the male stereotype traditionally connected with the perception of technology.

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Malaysia Transitions Toward a Knowledge-Based Economy

By Ramlee Mustapha and Abu Abdullah

The emergence of a knowledge-based economy (k-economy) has spawned a “new” notion of workplace literacy, changing the relationship between employers and employees. The traditional covenant where employees expect a stable or lifelong employment will no longer apply. The retention of employees will most probably be based on their skills and knowledge that can create advantages for the company over its competitors. Employers invest in the skills of their employees to improve productivity and the profitability of the company. Training costs can be substantially higher than that of general or academic education but are justified when the value of the company's earnings and productivity exceed the cost of the training. Numerous empirical studies regarding entry-level employee competencies from the perspective of employers have been conducted in both industrialized and

developing nations. The results of the studies found that employers prefer certain types of entry-level competencies of the prospective employees. This article provides an overview of workplace literacy from the perspective of the employers and also reviews pertinent literature regarding Malaysia's transition toward a k-economy.

K-Economy

In the information age, knowledge is power. The k-economy is based on a paradigm that focuses on intellectual capital as a prime mover. With knowledge replacing physical and natural resources as the key ingredient in economic development, education and human resource development (HRD) policies require rethinking. While there is no standard definition of a k-economy, the UK Department of Trade

and Industry defined it as a knowledge-driven economy in which the generation and exploitation of knowledge play the predominant role in the creation of wealth (Economic Research Services Department, 2000). Meanwhile, the Organization for Economic Cooperation and Development (OECD, 1996) defined a k-economy as an economy that is directly based on the production, distribution, and use of knowledge and information.

Investment in human capital is critical in a k-economy. Human capital theory views education and training as an investment that can yield social and private returns through increased knowledge and skills for economic development and social progress (Schultz, 1963). The economic argument in favor of knowledge-based education and training is linked to the perceived need of the global economy. It is based on the assumption that economic growth and development are knowledge driven and human capital dependent.

Despite a growing emphasis on knowledge-based education and training, minimal research exists with respect to the new workplace literacy especially from the employers' perspective. Therefore, this article attempts to provide an overview of workplace literacy from the perspective of the employers and also reviews pertinent literature regarding Malaysia's transition toward a k-economy.

Workplace Literacy: Employers' Perspective

Murphy and Jenks (1983) conducted interviews to identify the traits of successful entry-level professional employment applicants. The job opportunities investigated were either management trainee, junior-level professional, or apprenticeship positions. Employers clearly indicated that both functional and adaptive skills were needed. There was also a clear preference for certain types of skills. Nearly 40% of the responses related to communication and persuasion skills. Adaptive skills identified by the employers included a wide range of attitudes, personality traits, and work habits. Competition is a major factor that motivates industry to be more efficient and to employ strategies that will improve production, service, and product

quality. Because such strategies usually require workers' collaboration and teamwork, employers need creative, flexible workers who have a broad range of interpersonal and managerial skills.

Junge, Daniels, and Karmos (1984) surveyed 116 large U.S. companies to rate the knowledge and skills of employees related to mathematics, writing, reading, speaking, listening, reasoning, and science. The purpose of the survey was to determine the perceptions of employers regarding the workplace literacy that is important for successful employment. They found that speaking, listening, and writing followed by reasoning and reading skills were regarded as important requirements for successful employment. The most frequently cited qualities were good attitude toward work; willingness to adapt and learn; getting along with others; neat and appropriate appearance; promptness; infrequent absence from work; familiarity with basic computer knowledge; and good oral, written, and listening skills.

Research has also revealed reasons for rejection of job applicants and termination of employees. In a survey of employers conducted by the Advisory Council for Technical and Vocational Education in Texas, the reasons provided by employers for rejecting job applicants included little interest for wanting the job, past history of job hopping, poor communication skills, health problems, immaturity, personal appearance, poor mannerisms, personality, lack of job-related skills, and poorly completed application forms (Brown, 1976).

Zakaria (1988) studied the perceptions of Malaysian employers regarding essential employee traits and employability skills. Employers rated arrive on time, demonstrate a sense of responsibility, cooperate with the supervisor, and possess a positive attitude toward work as the major desirable employee traits.

In 1989, Lieberman Research Incorporated conducted a study of 1,000 senior executives of FORTUNE 500 companies to explore the beliefs of the executives regarding the American public education system (Lieberman Research

Inc., 1989; Passmore, 1994). Most of the responding employers were highly critical of the public education system. Approximately two thirds of the respondents asserted that their companies had difficulties hiring employees because of basic skill deficiencies of job applicants and that identifying potential employees with adequate basic skills was becoming more difficult. Clearly, employers preferred employees who were motivated, possessed basic skills, and had satisfied a higher performance standard.

The Employment and Training Administration of the U.S. Department of Labor and the American Society for Training and Development (ASTD) conducted a survey of employers seeking potential employees (Passmore, 1994). They found that many employers valued basic literacy—reading, writing, and computing. In addition, the employers preferred employees who had motivation to learn; could communicate, especially through listening and oral communication; could adapt through creative thinking and problem-solving skills; possessed effective personal management skills; had interpersonal, negotiating, and teamwork skills that made them effective work-group members; and could influence others to act through leadership skills. Moreover, employers preferred to conduct their own technical skills training but only with employees who possessed basic skills (Carnevale, Gainer, & Meltzer, 1990).

The Harris Education Research Center (HERC, 1991) assessed the views of employers, educators, parents, and students regarding American education. Employers clearly indicated that their new employees were borderline in terms of functional literacy, capacity to express themselves, and basic functional skills. In contrast, students and parents thought that their schools were doing well (Passmore, 1994).

The U.S. Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS, 1991) examined the literacy required to enter employment using interviews with business owners, public employers, union officials, and line workers. The SCANS report identified five major competencies and three foundation

areas that were required for entry-level job performance. Basic skills, thinking skills, and personal qualities formed the foundation on which the five broad competencies were constructed. Basic skills included reading, writing, arithmetic, mathematics, speaking, and listening. Thinking skills included creative thinking, decision making, problem solving, abstract visualizing of problems, knowing how to learn, and reasoning. Desirable personal qualities included individual responsibility, self-esteem, sociability, self-management, and integrity.

Distler (1993) studied attitudes and perceptions of Maryland's employers toward vocational education and employment training programs. The majority of the employers indicated that the present educational approach is not sufficient to train students effectively for the changing demands of the workplace. If vocational and training programs are to be effective, cooperation among educators, legislators, employers, and the community must be established.

An investigation by Custer and Claiborne (1995) supported previous research in which employers placed more emphasis on employability skills rather than on technical skills. They surveyed 299 U.S. employers in the health, trade, and industry occupational areas. The purpose was to explore employers' priorities regarding the types of skills they perceived to be critical to their needs and the workforce. The findings revealed that the most important skills cluster was employability skills. Basic skills ranked second and technical skills third.

A recent empirical research on the perceptions of Malaysian employers regarding employability and workplace literacy was conducted by Mustapha (1999). The purpose of the study was to examine employers' perceptions regarding the critical workplace literacy and employability skills of vocational graduates. The sample consisted of 120 employers from large and medium-sized manufacturing companies. The study found that employers believed that the completers of vocational and technical programs had better employment opportunities than completers of academic programs. Further, employers indicated that vocational and technical graduates possessed necessary technical

skills. However, employers were less satisfied regarding the graduates' motivation, communication, interpersonal, critical thinking, problem solving, and entrepreneurial skills. This clearly suggests that affective and employability skills should be integrated into vocational and technical programs. Technical competencies were perceived by Malaysian employers as the most important knowledge and skills that vocational and technical graduates should possess. They also believed that communication and interpersonal skills are important. These results seem to support previous research regarding the importance of employability skills (Custer & Claiborne, 1995; Greenan, Wu, Mustapha, & Ncube, 1998; HERC, 1991; Lieberman Research Inc., 1989).

Malaysia Transitions Toward Knowledge-Based Economy

The shift to the k-economy is part of a wider plan to achieve the objective of the nation's Vision 2020. Vision 2020 is a 30-year plan to "push" Malaysia to achieve a level at par with industrial nations in terms of economic performance and technological capability (Mustapha & Abdullah, 2000). With the move toward a k-economy, the country can achieve sustainable Gross Domestic Product (GDP) growth rates in the long run with knowledge playing a dominant role in driving productivity and sustaining economic growth. It is projected that through an information and knowledge-based economy, the level of the country's GDP can increase four fold within 20 to 25 years (Economic Research Services Department, 2000).

However, Malaysia currently lacks some of the critical elements to support the k-economy. Among them are the lack of adequate knowledge and skilled human resources, inadequacy of a k-economy supportive education and training infrastructure, a lack of R&D capability, a relatively weak science and technology base, a deficiency in institutional support and infrastructure, a slowly evolving financing system, and a lack of technopreneurs (Govindan, 2000).

The new global market calls for visionary leadership and the adoption and application of new management and organizational principles.

The old command-and-control management system that many Malaysian organizations are used to may not work in a new competitive environment. The education, training, and employment policies have to change. Employers need to recruit "knowledge" workers for higher skills jobs. This requires our education system to produce graduates with relevant knowledge, critical and higher order skills, and proper attitudes.

IT Infrastructure

Tangible evidence of Malaysia's commitment to the k-economy is the Multimedia Super Corridor (MSC). This 50 x 15 km wide corridor stretches from the center of Kuala Lumpur to Cyberjaya, a newly established city approximately 40 km south of Kuala Lumpur, and is designed to incubate high technology companies. When the MSC was first announced in 1995, it was estimated that the government would spend RM 28 billion (approximately USD 7.4 billion) to develop the infrastructure and facilities required to attract international high technology companies (Mohamed, Hasan, Dzakiria, & Kassim, 1999).

It aims at revolutionizing IT and multimedia industries by creating a massive corridor with a conducive environment for local and international companies wanting to create, distribute, and employ IT and multimedia products and services (Abdul Manab & Othman, 1999). MSC is also expected to place Malaysia as a regional and international technology and telecommunication hub. The MSC will propel the transfer of technology and become the test bed for R&D in high-tech industries (Mohamed et al., 1999).

Due to the increasing demand for knowledge workers to work in the IT and high-tech industries of the MSC, the Smart School program was adopted as one of the seven flagship applications. The flagship will support the government's plan to obtain the status of an industrialized nation by the year 2020 and to gain a competitive edge over other developing countries in the global economy (Mohamed et al., 1999). In the Smart School concept, learning will be self-directed, individually paced, contextualized, and reflective using IT as a prime enabler (Abdul Manab & Othman, 1999).

It is hoped that, eventually, all schools in this country will be smart schools.

Despite the MSC project, schools in Malaysia continue to lag behind other sectors such as business and entertainment in utilizing IT and multimedia technologies. A majority of schools still do not have enough computers and Internet facilities for most students to use frequently. However, during the last decade the increase in IT access and the emergence of new telecommunication technologies have somewhat changed how teachers perceive technology and its applications in teaching and learning.

The IT literacy among Malaysian students has not yet reached its satisfactory level. To reach its maximum potential requires full commitment, serious thinking, research, and experimentation. Although Malaysia has made great strides in enhancing its IT infrastructure, IT utilization and structure in educational institutions are still inadequate. Teachers and administrators should reevaluate and restructure the curriculum so that the curriculum is viable for IT literacy to be developed among students (Mohamed et al., 1999). Therefore, the administrators and educators should be urged to plan the curriculum carefully and systematically in meeting the needs of the society as a whole.

Policy Implications on New Workplace Literacy

Highest Level Commitment

The Malaysian government has already recognized the importance of adapting to this new economy and is committed to transform the economy from a production-based to a knowledge-driven economy. The prime minister during his official speech at the launching of the information technology campaign in 1997 stated that IT is at the forefront of the country's national socioeconomic planning and development. The government formulated the National Information Technology Agenda (NITA) in 1996 to provide the country with the direction and the way forward with IT. The NITA has spelled out a three-pronged strategy aimed at developing a knowledge society through building and developing the appropriate IT structure, the creation and development of IT-based applications, and human development effort.

In order to achieve this, the balanced development of three important, interrelated elements that involve people, infrastructure, and applications are stressed (Economic Research Services Department, 2000).

K-Economy Master Plan

The Malaysian K-Economy Master Plan outlines the major k-economy policy initiatives. Planned reforms in the education sector include further privatization, twinning arrangements with foreign institutions, and the construction of advanced technical institutes and community colleges. Infrastructure will be developed that allows for the use of electronic diagnostic tools in hospitals and networking among government departments, their suppliers, and their customers. Increased bandwidth is planned to facilitate greater e-commerce capacity. A draft of amendments to various financial regulations aims to create a more favorable investment climate for local and foreign firms, particularly those in designated high technology sectors. It also includes profit repatriation and taxation arrangements designed to lure foreign investors back. This is in addition to a very publicized crackdown on software piracy. Overall, the initiatives aim to address the serious shortages of knowledge and skilled workers in Malaysia and to attract much-needed foreign investment and expertise, particularly in alliances with local firms and institutions.

IT Literate Society

Reflected in a particular k-economy initiative, the "One Home-One PC" policy allows workers to withdraw their contributions to the Employees Provident Fund (a retirement fund) to purchase a personal computer. This initiative supports a long-term plan to link 25% of the population to the Internet by 2005. Another initiative is the "Internet Desa" (Internet for rural areas) program, which aims to provide Internet access and basic computer skills to people in rural areas via a networked personal computer located in their local post office.

National Information Technology Council

The National Information Technology Council (NITC) was established in 1994 to guide the country toward the knowledge empowerment of Vision 2020. The NITC aims

to enhance the development and utilization of IT as a strategic technology for national development. The NITC acts as a think-tank at the highest level and advises the government on matters pertaining to the development of IT in Malaysia (Infosoc Malaysia, 2000). The government's commitment toward the creation of a k-economy is also evidenced by the development of the Multimedia Super Corridor, the idea mooted in 1994, and the creation of a pioneer legal and regulatory framework encompassing, inter alia, the Communication and Multimedia Act, the Computer Crimes Act, and the Digital Signatures Act (Economic Research Services Department, 2000).

Development of Knowledge Workers

The creation of quality human resources is important in a k-economy. These individuals will form the backbone of the k-economy. Knowledge workers are versatile, autonomous, and highly skilled and are able to leverage and build knowledge to produce useful action with very strong and analytical skills. They are flexible and have a high tolerance for ambiguity. For Malaysia to produce a pool of k-leaders and k-workers, the educational system needs to be revamped and restructured. The focus should be directed to making the existing curriculum more innovative to help students to invent and develop a critical and analytical mode of thinking and ultimately create a sufficient pool of well-educated, highly skilled and strongly motivated workers (Economic Research Services Department, 2000).

The use of IT in teaching and learning should facilitate knowledge construction and engage learners in constructive, higher order, creative, and critical thinking (Jonassen, 1996). It should also develop team-based collaboration and communication skills for solving real-life problems. Teachers must redesign their instructional material to include the use of IT as a cognitive tool rather than a mere delivery medium.

In this area, the government has already taken the initiative of introducing the Smart School project, which was launched during the review of the Seventh Malaysia Plan (1996-2000). The objective of the project is to produce a new generation of IT-literate Malaysians who

are creative and innovative, adept with new technologies, and able to access and manage information to enhance the competitiveness and productivity of the economy. At the same time, the government is campaigning hard to woo back Malaysians who are now working overseas. In March 2000, the prime minister announced a campaign to attract 5,000 skilled foreign workers a year to help the nation into the information age to ensure a massive brain gain, an infusion of men and women of extraordinary talent, creativity, knowledge, skill, and other capabilities (Economic Research Services Department, 2000).

To advance Malaysia into the forefront of knowledge, investment in human capital is critical, as a k-economy demands creative, innovative, and knowledgeable human resources. It is for this reason that the state has continued to allocate a substantial portion of the national budget for financing the expansion and upgrading of education and training facilities. However, human resource development needs to be further intensified, particularly through public-private sector collaboration in building science and technology human resources as well as the intellectual capability and competency in management and entrepreneurship. In this regard, opportunities for lifelong learning for all levels of the workforce should be enhanced through this collaboration.

Rigorous Research and Development

The structure of the economy becomes less distinct in the k-economy. Nevertheless, the manufacturing sector, which accounts for more than one third of the GDP of the country, still continues to assume an important role in the k-economy. However, in view of the migration of the economy from production based to knowledge based, the manufacturing sector would have to gear up to adjust to the rapid change in technological advancement by improving its products through R&D and enhancing the pool of "knowledge" workers (Economic Research Services Department, 2000).

In a k-economy, it is crucial to develop the R&D and the services sectors. It is generally known that the level of development of the services sector, particularly the knowledge

Table 1. Knowledge-Workforce Among Selected Countries

Selected R&D Statistics (1997)			
Countries	K-Skills Workforce (as % of total workforce)	R&D/ GDP (%)	K-Skills in R&D (per million population)
Malaysia	10.7	0.3	87
Singapore	26.4	1.4	2,512
Korea	15.1	2.8	2,636
Taiwan	15.5	1.9	3,340
Japan	22.9	2.8	5,677

Note. Data source: Bank Negara Malaysia, 2000.

intensive segments of it, has become a key determinant of the national competitiveness. There are many compelling reasons for Malaysia to develop its services sector. To begin with, expanding this sector helps create national wealth: A positive correlation exists between high GDP per capita and the intensity of services activity in the economy, mostly because compensation levels in this sector normally surpass those in agriculture and manufacturing (Economic Research Services Department, 2000). Moreover, in economies with a strong emphasis on services, people tend to climb the “value-chain ladder” much more rapidly. It is generally believed that in the k-economy, the information-related industries and knowledge-intensive industries play the dominant role.

Innovation is one of the key success factors in a k-economy, and it is R&D that determines innovation. According to the OECD (1996), the proxies generally used to represent the production of new ideas and innovation is R&D expenditure and the number of patents. Based on some available relevant statistics (see Table 1), it is apparent that Malaysia currently has a relatively low k-workforce and R&D investment.

Creativity, Innovation, and Entrepreneurship

IT leaders and business gurus believe that

the new economy is about the power of ideas and knowledge, which is why it is important to encourage entrepreneurship in Malaysia. Entrepreneurship is a collaborative effort. It may be easy to generate ideas, but hard to provide a conducive environment to allow the ideas to kick-start and grow. School systems at all levels should include entrepreneurship in their curriculum. It should focus on creating new and innovative ideas by the students and converting them into full-fledged business plans for future use.

Infrastructure, Accessibility, and Connectivity

There must be affordable and equitable access and connectivity to ensure that all levels of society can participate in the new economy. Businesses and citizens must have access to a low-cost, high-speed communication infrastructure. This is key to balanced urban and regional development across the country. Reducing access costs plays a major role in this context. In terms of accessibility to the IT infrastructure, Malaysia performed better compared to other developing countries, but the situation reversed when compared with advanced countries. Table 2 shows the number of personal computers and Internet hosts in Malaysia vis-à-vis other countries.

Table 2. Indicators of Communication and Information Infrastructure Among Selected Countries

Indicators of Communication and Information Infrastructure in 1996		
Countries	No. of Personal Computers (per 1,000 population)	No. of Internet Hosts (per 1,000 population)
Malaysia	43	19
United States	362	442
United Kingdom	193	149
Japan	128	76
South Korea	132	29
Singapore	217	196

Note. Data source: Jaafar, 2000.

Lifelong Learning

With knowledge replacing physical and natural resources as the key ingredient in economic development, education and HRD policies must be given due priority. The approach to HRD must be balanced and holistic. There must be a genuine partnership among government ministries, especially the Human Resource and Education Ministries, and between the private and public sectors to strategize and implement a human resource policy that is directed towards fulfilling the objectives of a k-economy (Badawi, 2000). Because economic development is now more dynamic than ever due to rapid technological improvements and global competition, the skills needed to succeed in this new economy will be different. Few will be able to equip themselves with lifetime working skills just from their years of formal education.

Lifelong learning conducted through non-formal channels such as virtual universities and distance learning, with skill acquisition at all age levels, must be promoted if the human resource is to constantly stay abreast of new and rapid development in the k-economy. In the context of HRD, Malaysia needs to adopt a two-pronged strategy (Badawi, 2000). One is

to ensure that those who are currently unskilled or low skilled are given the opportunity to learn and train so that they can have a productive role in the k-economy. And second, incentives and opportunities must be given to those with the potential to keep on acquiring knowledge and skills. HRD must move every Malaysian up the skill ladder, and at the same time reward excellence by allowing all individuals to fulfill their potential. If the school and training systems fail to train and retrain the traditional workers, their existing skills may become obsolete in the new economic environment. If those with minimal education, knowledge, or skills are not given the opportunity to continue their education, they will lag behind and will be less likely to participate in the k-economy. Indirectly, the government will lose precious human capital that could have been harnessed effectively into a new economic paradigm. Therefore, HRD must be geared toward providing every citizen an opportunity to contribute at his or her optimum level.

It is evident that the Malaysian government is committed to building a critical mass of “knowledge” workers. Already under consideration are plans to build more advanced technical-

industrial training institutes and community colleges in addition to the establishment of more “second route” programs to provide school leavers the opportunity to learn new skills. There is also a need for greater alliances between universities and the private sector to encourage industrial placements and internships. Greater attention must also be given to training workers in the small and medium industries (SMI). Most of the SMI firms can’t afford to invest in training, retraining, and R&D.

Therefore, public sector HRD initiatives must prioritize SMI workers who have minimal opportunities to enhance their skills by their employers. At the same time IT training must be promoted, especially among working adults, to increase IT literacy among the workforce. School teachers should be given incentives to continue to upgrade their IT skills in light of the primacy of these tools in the k-economy. Civil servants and servicemen should also be given this training so that they are able to be absorbed into the technology intensive private sector upon the completion of their service. ICT training should also be extended to nonworking adults such as the disabled, senior citizens, and housewives so that they can contribute to the k-economy as virtual home-based workers, offering services through virtual interfaces such as the Internet.

In recognizing that HRD is a critical factor in a k-economy, smart partnerships between the public and private sectors should be established. In particular, the private sector must play a greater role in technical and vocational training in order to complement the efforts of the government. The government should continue to assist the private sector in training and retraining workers, but there must be a continued commitment from employers to encourage and provide incentives for their workers to acquire new knowledge and skills.

What It All Means

Research has shown that employers perceive technical competency as the critical workforce literacy. Communication and interpersonal skills are also essential. Other skills include critical- and problem-solving skills, self-motivation, and management skills.

However, to compete and survive in the era of a k-economy and globalization, a new set of workplace literacy is deemed necessary. The k-economy requires knowledgeable, skilled, dynamic, creative, and innovative human resources. In addition, the new global market calls for visionary leadership and the adoption and application of new management and organizational principles. The old command-and-control management system that many Malaysian organizations are used to may not work in a new competitive environment. Thus, education, training, and employment policies have to change. Employers need to recruit more “knowledge” workers for higher skills jobs. This requires the education system to produce graduates with relevant knowledge, critical skills, and proper attitudes. Teacher training programs must also undergo substantial transformation. To create a new kind of workplace literacy based on the k-economy, some of the recommendations include:

- Create a technology roadmap to search for “niche” technology for Malaysia.
- Identify future knowledge and competencies.
- Invest in human capital.
- Provide a world-class telecommunication system that is accessible to all at competitive prices.
- Create an information society for all, where every citizen can play an active role in the k-economy.
- Promote the use of information technologies in all sectors.
- Equip all schools with high-speed Internet connections and multimedia PCs in sufficient numbers.
- Adapt the school curriculum and train the teachers in IT.
- Provide opportunities for lifelong learning.
- Invest in extensive research and development in order to increase the country’s competitiveness both regionally and internationally.
- Establish systematic R&D networks linking businesses, educational institutions, and research institutes.
- Recognize and reward individuals or industries that are involved in creative

and innovative work practices.

- Promote smart partnerships between the public and private sectors.

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Books Briefly Noted

Alexander, Brian (2003). *Rapture: A raucous tour of cloning, transhumanism, and the new era of immortality*. New York: Basic Books. ISBN 0-7382-0761-6, pb, \$15.00.

Brian Alexander takes readers into the surprising stories behind cloning, stem cells, miracle drugs, and genetic engineering to show how the battle for the human soul is playing out in the broader culture—and how the outcome will affect each and every one of us. *Rapture's* Dickensian cast of characters includes the father of regenerative medicine, an anti-aging guru, and a former fundamentalist Christian and founder of the company that reportedly cloned the first human cell. This motley crew is in part being united by the force of the opposition: a burgeoning coalition of conservative Republicans, the Christian right, and the Greens—predicting impending doom should we become adherents of the new bio-utopian faith. The book is irreverent, shocking, and highly entertaining as it seeks to separate hype from reality.

Anderson, John D., Jr. (2004). *Inventing flight: The Wright brothers and their predecessors*. Baltimore, MD: The Johns Hopkins University Press. ISBN 0-8018-6875-0, pb, \$18.95.

The invention of heavier-than-air flight craft counts among humankind's defining achievements. In this book, the renowned aeronautical engineer John D. Anderson, Jr., offers a concise and engaging account of the technical developments that help to explain the Wright brothers' successful first flight on December 17, 1903. While the accomplishments of the Wrights have become legendary, we do well to remember that they inherited knowledge of aerodynamics and considerable flying-machine technology. Beginning with the earliest attempts at flight, Anderson notes the many failed efforts. He tells the fascinating story of aviation pioneers such as Sir George Cayley who proposed the modern design of a fixed-wing craft with a fuselage and horizontal and vertical tail surfaces in 1799 and of William Samuel Henson who won a patent in 1842 but never flew. He also examines the crucial contributions of German engineer Otto Lilienthal to the science of aerodynamics. With vintage photographs and informative diagrams, *Inventing Flight* will interest anyone who has ever wondered what lies behind the miracle of flight.

Beattie, Andrew, Paul R. Ehrlich (2004). *Wild solutions: How biodiversity is money in the bank*. New Haven, CT: Yale University Press, 2nd edition. ISBN 0-300-10506-1, pb, \$16.00.

In this fascinating and abundantly illustrated book, two eminent ecologists explain how the millions of species on Earth not only help keep us alive but also hold possibilities for previously unimagined products, medicines, and even industries. In an afterword written especially for this edition, the authors consider the impact of two revolutions now taking place: the increasing rate at which we are discovering new species because of new technology available to us and the accelerating rate at which we are losing biological diversity. Also reviewed and summarized are many "new" wild solutions, such as innovative approaches to the discovery of pharmaceuticals, the "lotus effect," the ever-growing importance of bacteria, molecular biomimetics, ecological restoration, and robotics.

Bergeron, Kenneth D. (2004). *Tritium on ice: The dangerous new alliance of nuclear weapons and nuclear power*. Cambridge, MA: The MIT Press. ISBN 0-262-52433-3, pb, \$15.95.

This winner of the Gold Award in Political Science in 2002 is now in paperback. For more than 50 years after the start of the nuclear age, the U.S. followed a policy barring commercial nuclear reactors from producing the ingredients of nuclear weapons. But in the fall of 2003 all that changed when a power plant operated by TVA started making tritium for the Department of Energy at the same time producing electricity for the commercial grid. Tritium, a radioactive form of hydrogen, is needed to turn A-bombs into H-bombs, and the commercial nuclear power plant that was modified to produce tritium is of a type called "ice condenser." This book provides an insider's perspective on how this nuclear policy reversal came about, and why it is dangerous.

Bødker, Keld, Finn Kensing, Jesper Simonsen (2004). *Participatory IT design: Designing for business and workplace realities*. Cambridge, MA: MIT Press. ISBN 0262-02568-X, hc, \$50.00.

The goal of participatory IT design is to set sensible, general, and workable guidelines for the introduction of new information technology systems into an organization. Reflecting the latest systems-development research, this book encourages a business-oriented and socially sensitive approach that takes into consideration the specific organizational context as well as first-hand knowledge of users' work practices and allows all stakeholders—users, management, and staff—to participate in the process. Drawing on the work of a 10-

year research program in which the authors worked with Danish and American companies, the book offers a framework for carrying out IT design projects as well as case studies that stand as examples of the process.

Broadbent, Marianne, Ellen Kitzis (2004). *The new CIO leader: Setting the agenda and delivering results*. Boston: Harvard Business School Press. ISBN 1-59139-57-1, hc, \$35.00.

Two converging factors—the ubiquitous presence of technology in organizations and the recent technology downturn—have brought Chief Information Officers to a critical breaking point. Then can seize the moment to leverage their expertise into a larger and more strategic role than ever before or they can allow themselves to be relegated to the sideline function of “chief technology mechanic.” Drawing on extensive Gartner, Inc. interviews and research with thousands of CIOs and hundreds of companies, the authors outline the agenda CIOs need to integrate business and IT assets in a way that moves corporate strategy forward. Dozens of case examples appear throughout the book including AXA, Banknorth, British Airways, Citigroup, Commerce Bank, Disney, SKF, Starwood, Unicef, and U.S. city and federal agencies.

Bunch, B. & Hellermans, A. (2004). *The history of science and technology: A browser's guide to the great discoveries, inventions, and the people who made them from the dawn of time to today*. Boston: Houghton Mifflin. ISBN: 0-618-22123-9, \$40.00.

Have you ever wondered how bridges are built? Do you know what medical discoveries led to the introduction of vaccines and antibiotics? Do you know why PCR (polymerase chain reaction) is one of the pillars of the biotechnology revolution? *The History of Science and Technology* is the ultimate resource for answers to questions about the when, what, why, and how of science and technology.

This accessible reference work, organized within 10 major periods of history, is a comprehensive, chronological guide to the scientific discoveries and technological innovations from the earliest periods of recorded history into the 21st century.

With more than 7,000 concise entries in such fields as archaeology, biology, computers, food and agriculture, medicine and health, and transportation, the book covers trends, important breakthroughs, births, deaths, and other useful information. Features include:

- in-depth section introductions that place each epoch in context
- short essays on intriguing topics, such as the history of DNA, the transit of Venus, the nature of light, and the relationship between electricity and magnetism
- 300 brief biographies of such personalities in science and technology as Galileo, the first scientist of the scientific revolution, and Charles Babbage, designer of the first mechanical computer
- 300 black-and-white drawings and photographs

Most entries are cross-referenced so that the reader can easily trace connections over time. This arrangement allows the reader to choose between following the development of a specific field through history and focusing on the breadth of innovation during a certain period.

Browsable yet richly detailed, *The History of Science and Technology* is an invaluable desktop reference for general reader and educator alike.

Campbell-Kelly, Martin (2004). *From airline reservations to Sonic the hedgehog: A history of the software industry*. Cambridge, MA: The MIT Press. ISBN 0-262-53262-X, pb, \$16.95.

From its first glimmerings in the 1950s, the software industry has evolved to become the fourth largest industrial sector in the U.S. economy. Starting with a handful of software contractors who produced specialized programs for a few existing machines, the industry grew to include producers of corporate software packages and then makers of mass-market products and recreational software. This book tells the story of each of these types of firms, focusing on the products they developed, the business models they followed, and the markets they served.

Cassidy, David C. (2004). *J. Robert Oppenheimer and the American century*. New York: Pi Press. ISBN 0-13-147996-2, hc, \$27.95.

The story of J. Robert Oppenheimer, physicist extraordinaire and the man who led the scientific team for the Manhattan Project that built the atomic bomb, has fascinated many people. Award-winning author David Cassidy, using previously unexamined documents, presents for the first time an integrated and coherent account of the man within the context of the nation he loved and so profoundly affected. Cassidy has crafted a richly detailed, gripping, and nuanced look at the theorist who theorized about black holes, the humanist who read Sanskrit, the man who loved his family, and the statesman who confronted the hardest

moral dilemmas and scientific problems of his age. The hidden story of the political and social forces that shaped the world in the 20th century is the rise of American science, and Oppenheimer was at its epicenter. His story is at the crux of America's astonishing rise to power and an insight into the technological progress of our nation.

Chadarevian, Soraya de, Nick Hopwood, Eds. (2004). *Models: The third dimension of science*. Stanford, CA: Stanford University Press. ISBN 0-8047-3971-4, pb, \$24.95.

Now that "3-D models" are so often digital displays on flat screens, it is timely to look back at solid models that were once the third dimension of science. This book is about wooden ships and plastic molecules, wax bodies and a perspex economy, monuments in cork and mathematics in plaster, casts of diseases, habitat dioramas, and extinct monsters rebuilt in bricks and mortar. These remarkable artifacts were fixtures of laboratories and lecture halls, studios and workshops, dockyards and museums. Considering such objects together for the first time, this interdisciplinary volume demonstrates how, in research, as well as teaching, 3-D models played major roles in making knowledge. Accessible and original chapters by leading scholars highlight the special properties of models, explore the interplay between representation in two dimensions and three, and investigate the shift to modeling with computers. The book is fascinating reading for anyone interested in the sciences, medicine, and technology, and in collections and museums.

Clarke, David, Ed. (2005). *Theory of technology*. New Brunswick, NJ: Transaction Publishers. ISBN 0-7658-0844-7, pb, \$29.95.

The history of technology is often troubled by good ideas that do not, for one reason or another, take off right away—sometimes for millennia. Sometimes, technology comes to a standstill, and sometimes, it even reverses itself. Thus, unlike science, which seems to proceed at a reasonable and calm rate, the progress of technology is difficult to theorize about. David Clarke brings together 10 authors from a range of disciplines who try to understand technology from a variety of viewpoints. These essays originally appeared in two issues of *Knowledge, Technology & Policy* in 2002 and 2003.

Eglash, Ron, Jennifer L. Croissant, Giovanna Di Chiro, Rayvon Fouché, Eds. (2004). *Appropriate technology: Vernacular science and social power*. Minneapolis, MN: University of Minnesota Press. ISBN 0-8166-3427-0, pb, \$25.95.

From the vernacular engineering of Latino car design to environmental analysis among rural women, to the production of indigenous herbal cures—groups outside the centers of scientific power persistently defy the notion that they are merely passive recipients of technological products and scientific knowledge. This work is the first study of how such "outsiders" reinvent consumer products—often in ways that embody critique, resistance, or outright revolt.

Emsley, John (2004). *Vanity, vitality, and virility: The science behind the products you love to buy*. New York: Oxford University Press. ISBN 0-19-280509-6, hc, \$28.00.

Acclaimed popular science writer John Emsley explains the nature and behavior of about 40 ingredients that play important roles in every aspect of modern living. There are chapters on cosmetics, foods, sex, hygiene, depression, and on four unexpected ways in which modern products improve our lives. So if you have ever asked yourself whether cosmetics can deliver what they promise, whether certain spreads really can reduce cholesterol, whether nitrates in water are a cause of cancer, or whether Prozac is as safe as they say, dive into *Vanity, Vitality, and Virility* and discover things you always wanted to know.



Promoting Excellence in Preparation and Excellence in Practice

Volume XXX, 2004
No. 4 Fall 2004

The Journal of Technology Studies



A refereed publication of *Epsilon Pi Tau* The International Honor Society for Professions in Technology.

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The Journal of Technology Studies (JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc., a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0305. Use this address or jots@bgnet.bgsu.edu for subscription matters or purchases.

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The opinions expressed by the journal's authors are not necessarily those of the Board of Directors, staff, or members of Epsilon Pi Tau.

Two print issues per year are mailed to all members of the society and to academic and general libraries around the globe. Issues that are published online only, the aforementioned printed issues, and past issues are available free online at scholar.lib.vt.edu/ejournals/JTS.

The journal is currently indexed in: Current Index to Journals of Education (USA); International Bibliography of the Social Sciences (IBSS) (UK); and the International Vocational Education and Training and Research Database at <http://www.ncver.edu.au> (Australia).

Separate articles or complete issues are also available in a variety of media forms from: ProQuest Information and Learning Co., P.O. Box 1346, Ann Arbor, MI 48106-1346

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A general guide to the breadth of topics of potential interest to our readers can be gained by consideration of the 17 subclasses within "Technology" of the classification scheme of the Library of Congress, USA <lcweb.loc.gov/catdir/cpso/lcco/lcco_t.pdf>. This includes engineering and allied disciplines, informatics in its many manifestations, industrial technology, and education in and about technology.

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Printed in the United States of America by Kennedy Printing Company, Findlay, Ohio.

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Articles

Russia Develops Educational Standards for Higher Vocational Training in the Technology and Entrepreneurship Specialty

A. A. Karatchev and N. N. Lavrov

This article may not bring the reader to a sense of closure, or a conclusion as to what will happen in Russian vocational education. It does offer insight into what Russian educators are facing on a daily basis as they try and find and pursue the best course of action as they attempt to create a curriculum that will address the major needs of Russian society now and in the immediate future. This article may make more impact on our readers if they knew that the average salary that a Russian university professor makes is equal to one U.S. dollar a day, or that most schools either have no computers or ones that can only run DOS programs, or that Internet access is still a dream of the future for most Russian students and professionals.

This article presents issues related to training teachers of technology and entrepreneurship in Russia's higher educational establishments, that is, those who will actually represent in 1st to 11th forms of Russia's general schools technological units, assigned to the technology educational field.

Technology, as a part of general education, ensures that the school children acquire technological competence, being in tandem with skills to master diversified means and ways to transform and transfer materials, energy, and data; to estimate the economy's efficiency and possible environmental implications of technological activity; and to set up their own course for life and career. It facilitates building up general skills and habits of work, simultaneously develops creativity, and enables the tackling of practical problems. In the system of general education, technology is aimed so that the school children are able to:

- Form technological knowledge and skills as the basis for successful creative and developing activity.
- Acquire inner need and deferential treatment of work and its products.
- Acquaint themselves with different types of vocational activity and contribute

to their career self-determination.

- Reveal and develop creativity; build up and widen their cognitive interest.
- Form their working, graphical, business, ecological, informative, ethic, and esthetic culture.
- Enjoy every opportunity for self-actualization, self-assertion, and socialization.

Used to this effect, technology concurs to develop wholeness of one's personality, harmonically combining inner need for both physical and mental work, continuous self-education, and self-development.

In Russia, teachers of technology are being trained in 69 pedagogical universities at the faculties of technology and entrepreneurship. Their training, in respect to future pedagogical specialty, is governed by the State Educational Standard for Higher Vocational Training (SESHVT). To educate a teacher, SESHVT includes the following sections:

- General humanitarian and socioeconomical disciplines (philosophy, history, sociology, economy, etc.) – 1,500 hr.
- General mathematical and natural-science disciplines (higher mathematics, physics, chemistry, etc.) – 1,000 hr.
- General vocational disciplines (pedagogy, psychology, teaching methodology, etc.) – 1,600 hr.
- Disciplines of subject training (engineering science, electro-radio engineering, technological practical training, information technologies, marketing, management, etc.) – 4,334 hr., including 900 hr. taken by disciplines referred to as a specialization.

In addition, there are standards developed to acquire both basic and optional specialties.

When, in 2000, the Ministry of Education of the Russian Federation adopted SESHVT for the second generation, it actually meant reviewing the achievements and starting a new essential stage of theoretical and practical work in the

field. Its results, worded in the respective standard regulations, teaching and methodological documentations, that is, curricula, educational programs, textbooks, training aids, methodological recommendations, etc., shall govern training of a specialist-teacher in the near future. Now within the university level, where the powers have been delegated, the issue of SESHVT's unambiguous interpretation has definitely become of prime importance. In view of this we, as the authors of SESHVT on the technology and entrepreneurship specialty, would like to dwell on certain conceptual notions, actually the staple of standard's development and application.

Presently, there is no uniformity among Russia's analysts in regard to how to treat issues of higher education standardization. And, standardization of higher pedagogical education as a subsystem of the general higher vocational education is definitely not an exception. In our opinion, SESHVT, specifying general parameters and requirements to train a specialist-teacher, can be considered as a methodological foundation for functioning and developing the respective educational system. That is why, taking a teacher of technology and entrepreneurship training as an example, we have been governed by the absolute importance, necessity, and expedience to draw up a federal regulatory document in view of the:

1. Insistent need to preserve education uniformity and, consequently, to ensure similarity of educational programs applied by Russia's pedagogical universities concerning their aims, objectives, requirements, and results of training a specialist-teacher.
2. Strategic significance to legislatively support academic freedom of universities, related to their self-independence in forming the whole package of documents to determine the respective educational program.

It is worth pointing out that practical implementation of the first requirement should in no way imply the absolute uniformity of university educational programs identical training of teachers based on previous years' common curricula. Equally, meeting the second requirement will

not justify unlimited educational freedom of the 90s. In other words, we regard the state standard as some sort of controller to maintain the required data balance, theoretically exclusive concepts, which dialectical uniformity makes it possible to establish a functioning system of democratic education.

We believe, and have used this as conceptual footing to develop the standard, that in the foreseeable future Russia's higher pedagogical education should be primarily oriented toward university education of a degree-holder specialist. This assumption has not been inspired by conservatism, the fashion of today; it has actually resulted from tough-minded and thorough analysis of Russia's education system. To a certain extent, such a classical introduction of the issue might seem too evident, so we would like to pinpoint that not only does it correspond to the traditional system of education in Russia and meet requirements of the general school, but it also forms a natural basis to modernize the entire system.

Moreover, the above-stated assumption implies our answer to the question concerning the least required educational level for a teacher to effect technological education in the school. The law of the Russian Federation on Higher Vocational Education stipulates three stages of education each of which should be sufficient to confer a certain degree or qualification to a university graduate. What we are driving at is a bachelor's degree (qualification), degree-holder specialist qualification, and a master's degree (qualification).

Unfortunately, the law does not differentiate between a bachelor's or master's qualification and degree. Nor does it comprehensively specify whether bachelors and masters are to be simultaneously educated for a degree and qualification. These abstrusities complicate the practical implementation of law-stipulated patterns of education, where diversity should theoretically enable a graduate to individually set up his or her educational trajectory. Not only, and it is its major advantage, can he or she pass "stages" in a strictly limited one-way direction, but he or she as well can get out of, or even alter direction within, a unit of the educational trajectory.

As it is, these patterns are far from being entirely realized in all spheres of professional activity due to the unequal demands required of graduates, determined by the peculiarities of their respective field. Quite often it results in system contradictions, solved only by generalizing further practical experience. To illustrate this point, let's analyze as an example the place of a "teacher-bachelor" in general education. In Russia, a school "discipline teacher" is assigned to the main subject; traditionally the position is taken by a specialist-teacher, holding a degree corresponding to the particular discipline. Other appointments, requiring lower qualification such as tutors, assistant-teachers, etc., are simply not available in Russia's modern school system. Qualified bachelors "added" to a specialist-teacher at Russia's schools will drastically imbalance the latter. Teachers with different professional backgrounds could apply for similar positions. But, equal professional duties evidently presuppose equal qualification.

Therefore, it seems justified to acknowledge that there is no need for graduate teachers with a bachelor qualification. Otherwise, mere admission of a bachelor-teacher to a school might threaten training of the more "expensive" specialist-teacher, with similar academic, but considerably higher, professional level. This would lead to a trivial reduction in teachers' educational qualifications and the subsequent general decline in Russia's entire educational system.

The approach mentioned above should not be considered as an attempt to generally abandon training of the bachelor-teacher. If a bachelor's training ends with granting him or her only a degree, it will not result in the above contradiction. In fact, a bachelor's degree will confirm the level of academic training, enabling the graduate to choose ways and forms of his or her further activity. It will be up to him or her whether to go on with his or her education, taking the subsequent stages, or to assume it completed and switch to any practical activity, i.e., entrepreneurship. However, professional pedagogical activity will be open, providing that the stages following the bachelor's degree are successfully mastered. So a bachelor with a degree and fundamental academic education, in terms

of the profession, is a bit "semi-finished," fit for further multitudinous "additional training" (including taken on his or her own), thus sufficiently widening his or her possible realization as a pedagogue.

Analyses carried out in respect of "a degree-holder specialist" and "a bachelor" with a preferential role of the former in higher pedagogical education can be applied to notions of "a degree holder-specialist" and "a master." A master's stage can be attained by two means: either by graduating from a bachelor's educational program or receiving a specialist's degree. A master graduate is educated to work as a teacher of a specific discipline at school, to carry out research work in the field of education, to teach at higher school within the chosen direction, etc.

In context of the present article, the key factor is the possibility for a master to conduct his or her professional activity at school. So, irrespective of any type of educational program, professionally a master should not be educated in any diminished degree from that of a respective degree-holder specialist. Nothing less than practice can provide an answer to the path of higher pedagogical education in Russia. The given considerations only justify training a degree-holder specialist as top priority in university education for a future technology teacher. Moreover, the given choice in no way limits any democratic chances to develop higher pedagogical education in the field. Naturally, a specialist level of training set up by general school requirements determines the limits used to educate a bachelor and a master of technological education; the difference is that the "upper" boarder is applied for a bachelor and the "lower" one for a master.

While developing the standard, we have faced another equally significant problem, that is, how to maintain a real level of university academic freedom when working out respective educational programs to train a teacher of technology and entrepreneurship. Currently Russia's legislation grants universities freedom to work out their own educational programs, curricula, etc. On the other side of the spectrum, the unified federal area, tendency towards simplicity

of certifying procedures, need for opportunities to change universities, etc., have resulted in availability and a recent increase in unification tendencies at higher pedagogical school management.

Formal data implementation, being a quite positive factor as a whole, specifies the hazard of shifting back to the traditional, strictly regulated pattern of educating a specialist-teacher; it questions the availability of the university (academic) freedom. In this context, the standard, due to its regulatory essence, might be considered as a perfect executive instrument. It seems worth pointing out that the preceding standards bore an air of strict unification concerning humanitarian, vocational, and pedagogical disciplines, with the universities free only to stipulate their curricula sequence with evidently low variability due to the natural logic of their subject. In developing the first generation standards, it was assumed that a thesaurus approach would constitute a democratic basis for implementation. Unfortunately, for various reasons too lengthy to discuss in this article, no significant results were obtained in the course.

Presumably, because the standardization of Russia's higher pedagogical school has not been developed enough and there are a number of mutually contradicting approaches, the problem cannot yet be unambiguously resolved. So, the authors are forced to apply largely imperative approaches. It essentially complicates the situation, because the nonavailability of the objective basis for a standard's development enables the authors to impose their subjective views. It becomes possible to introduce in the standard certain units, that match their personal preference, so disciplines might be adopted without wide appraisal. Not only is this problem quite familiar for Russia's higher pedagogical school, but it can be classified as common for enacting federal regulations. One can find a lot of examples to the effect in the former practice of working out and adopting the state standard curricula, as well as new generation standards. Presently the situation is worsened by a much too-detailed obligatory minimum act of standards used to educate a specialist, as well as by the simplified order to adopt the standards.

Traditionally, one solution to the given problem has been to facilitate a certain time budget. This provides for studying the disciplines of the regional component and the disciplines chosen by a university; as a whole it equals to 20% of a student's total general education. In our opinion, the given measure, though necessary for vocational education variability, fails to overcome the influence of the negative factors under discussion. At best we can only claim a reduction in their impact.

We believe that the necessary thing to maximally democratize specialist-teacher's training at the university is the discipline's maximum integrity, stipulated by the standard obligatory minimum and by the model federal curricula. On the one hand, it ensures a common federal approach towards curricula; on the other hand, universities are granted the opportunity to develop their own structure of the respective educational courses.

The offered approach has been used to develop the structural pattern to train teachers of technology and entrepreneurship in respect to their subject. In general, the principal structure used in the former standard has been preserved, stipulating a student's training on cycles of general technical, technological, entrepreneurship, creative, design, and other disciplines. This approach corresponds to Russia's experience in educating teachers of technology and is continuously justified by pedagogical practice. Ambiguity of specific subject training for teachers of technology and entrepreneurship is largely determined by introducing federally mandated courses, namely, Applied Mechanics, Engineering Science, Info-Technology, Electro-Radio Engineering, Graphics, Fundamental Entrepreneurship, Fundamental Designing Disciplines, and Technological Practical Training. Amounting to 59% of a subject's training to become a teacher, the disciplines predetermine uniformity of the respective curricula. Simultaneously, they do not violate academic freedom of teaching because their interactivity ensures a wide range of their individual fulfillment within a certain university.

Finally, the last, but not the least essential, issue reflected in the standard is the necessity

of considering the peculiarities of Russian technological education. We mean separate training in engineering, housekeeping, farm-industry production, etc. Each direction can be pursued in variants depending on regional conditions and requirements, state of the teaching and material resources of educational institutions, wishes of the school children and their parents, etc. The mentioned multi-discipline (and multi-aspect) essence of technological training is complicated, over and over again, by the need to follow the federal requirement of uniformity towards acquiring minimum general technological knowledge and skills by the school children.

These peculiarities of technology have been envisaged in the standard by structural organization of the Subject's Training Disciplines unit, where the so-called "Disciplines of Specialization" are introduced. The required invariant constituent concerning the professional aptitude of the future teacher of technology and entrepreneurship is ensured by the above federal integrative disciplines, being basic to further education. The Disciplines of Specialization, multi-variant by their essence, lay down the guidelines for the in-depth professional specialization of a teacher to be, that is, a person capable of fulfilling this or that variant of technology.

As compared to the first generation standard, the new standard somewhat increases the time allocated for disciplines of specialization

up to 900 hours (amounting to 21% of the subject's training time, though even this may seem insufficient). Should it happen, we think it is worthwhile to refer to the standard in part, allowing for the use of time stipulated for the regional component as well as the so-called chosen disciplines (amounting to 20% of the subject's training) required to enlarge specialization disciplines.

By developing the new standard the authors didn't manage to realize all the ideas stated in some of their latest articles and submissions in Russian professional press (Karatchev & Kaplin, 2000; Karatchev & Lavrov, 2000; Karatchev & Yakobson, 2001; Lavrov, 1999, 2000). The main cause of it was the necessity of providing quite a high level of the uniformity of the standards for various pedagogical specialties. Notwithstanding this, we still hope that a new educational standard on the technology and entrepreneurship specialty shall make it possible to enhance training of specialists in Russia's pedagogical universities.

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The Law and Technologists: Implications for the Technology Curriculum

Joan Forret

A general theme of technology education posits that participation in technology studies will result in outcomes and (hopefully) benefits for the wider society. Such an expectation is reflected in the New Zealand Technology Curriculum document where the aim of technology education includes enabling students "to achieve technological literacy through the development of: understanding and awareness of the relationship between technology and society." Although technology studies has developed as a distinct curriculum area in many countries, it is important to recognize that technology is not recognized as such by many of those in decision-making roles within our various societies. While educators have attempted to identify technology as a separate endeavor and knowledge system from science (Layton, 1993), that distinction is not necessarily perceived by those who may be very influential in making decisions that have important legal, economic, and social consequences. Research into the views of legal decision makers concerning science and scientific evidence has revealed a very wide spectrum of understanding and expectations of expert witnesses. Judges not only interpret expert technical opinion evidence differently from those within the expert community, they also interpret that evidence differently from each other. In addition, judges and other lay decision makers have various expectations of

the expertise and credibility of expert witnesses, and those expectations need to be met to ensure that appropriate consideration is given to their evidence. Technologists give crucial engineering, biochemical, and environmental opinion testimony that can have implications for the suitability of projects involving vast capital investment and the potential for serious environmental, social, and economic effects. Technologists also give evidence in criminal proceedings, and the credibility of that testimony will often be the difference between a guilty or not guilty verdict. Regardless of the type of legal system or social structure within a community, legal decision making will involve inquiry and an increasing reliance on expert opinion. Thus, it is crucial that in any program of technology education, lay perceptions and misconceptions are anticipated and accommodated so that technologists are taught how to effectively communicate their work and the importance of that communication as an aspect of the integration of technology into society (Jones, 1997).

Research with the New Zealand Environment Court

In New Zealand the environment court hears all appeals from decisions made by local authorities under the provisions of the Resource Management Act 1991 (RMA). This act

provides that all local authorities must have planning documents that cover the management of natural resources. Any activity that is not expressly permitted by such a planning document must be authorized by a resource consent. Thus, the court hears a lot of appeals arising from the proposed contents of local authority planning documents and also from those aggrieved at the grant or refusal to grant a resource consent. The subject of appeals varies greatly and can range from relatively minor land use matters, such as approvals for a residential subdivision, to consideration of applications for marine farming or multimillion dollar mining developments that may involve serious environmental and engineering considerations. A failure by an expert witness to effectively communicate his or her opinion on any of the matters significant to a particular proposal may result in the failure of the project at a vast cost to the applicant or, conversely, the failure to prevent a project at a vast cost to the environment itself and also to the wider community.¹ (See also Ayd & Troeger, 1999.)

For most hearings that involve the presentation of scientific or technical evidence, the court sits as a panel of three members, comprising an environment judge and two environment commissioners. The judge is legally qualified; however, the environment commissioners come from a range of backgrounds. The RMA requires that the court has a mix of knowledge and experience including commercial, local government and community affairs, resource management, environmental science and engineering, surveying and mining, and cultural issues relevant to Maori being the indigenous people of New Zealand.

In order to canvass the views of the court regarding the role of science and scientific witnesses, I interviewed all eight judges and 13 of the 17 commissioners.²

Classification of Expert Evidence

Technical Expertise

Interview results show that the court could be divided into three unequal groups concerning their understanding of the nature of science. The largest group described science and scientific evidence to include the traditional physical sciences and technology in a wide range of forms, under a general umbrella of technical expert evidence. This group attributed all types of technical evidence to a general category of scientific evidence, including medicine and all aspects of engineering evidence. Many in this group, which comprised four judges and five commissioners, perceived the uniting concept of science to be the empirical basis of data.

Another theme within this technical expertise group was the notion of a methodological basis for the evidence. For example, when one judge who included engineering and medicine under the umbrella of science was asked about his categorization of sociological evidence, he answered affirmatively because “they are giving opinions based on analyses...conducted in, well what I would hope, would be...using the scientific method.”

His understanding of scientific method was further described as “the principle of, and gaining systematic formulation of knowledge and in a way that can be tested, tested by replication, I think.”

Another member of this group (a commissioner) described the features of pure science as “incontrovertible proof and by incontrovertible, the only proof that’s incontrovertible is proof that can be repeated and repeated and repeated and you come up with the same answer. Reproducibility of result. That’s pure science.” This interviewee had previously indicated that precise technical evidence could be categorized as scientific; however, she described the social sciences as “garbage” due to their “inexactness.”

¹ The approval of an application by the government to build a high dam at Clyde, which resulted in the flooding of a fertile valley in intensive horticultural production in the South Island in the 1980s, is such an example. The proposal was vigorously opposed at the time and has since been identified as contributing a significant cost to the country as the result of continued engineering expenses and debt burdens, and the extra hydro electricity produced is not ever expected to balance those costs.

² In order to maintain confidentiality, I have coded all of the interviewees as judge or commissioner only and my research findings refer to all of the judges as “he” and to all of the commissioners as “she.”

The third major theme uniting the technical expertise group concerned the nature of witnesses' qualifications. This view is well illustrated by the following comments from a commissioner in response to a question asking what makes evidence scientific: "[A] person with discipline...with academic skills and training, qualifications...of a scientific background. ...they have got to have a scientific training, academically, and...practiced in that field." Many of this group preferred to discuss evidence as either expert or not and treated all forms of technical evidence under the same umbrella as science.

Hard Science vs. Applied Science

The second group of six commissioners and two judges had a view that technology and technical evidence was different from what they described as "pure" or "hard" science. Most of this group had a view of "applied" versus "pure" science, although they often saw that categories, particularly within engineering, could be rather blurred depending on the evidence being presented. The following comments from a commissioner most clearly illustrate the approach of this group:

I suppose you really have to distinguish between science and applied science and medicine would have to be applied science, I would say, except for those at the vanguard of research. The same thing, engineers are applying science that somebody else has discovered for the main part.

All Evidence Is Scientific

The third group, comprising two judges and two commissioners, held the view that any expert evidence, and in fact any admissible evidence, was necessarily scientific. These interviewees answered with reference to expert, rather than scientific, evidence.

The "all evidence is scientific" group can be best illustrated by the following comments from a judge when asked if he perceived a difference between evidence and scientific evidence: "I don't quite. It's all evidence, but I think probably what you're getting at is whether it might be relevant in a certain situation." When the same interviewee was then asked what

makes expert evidence scientific, he continued: "It never addressed my mind, it would never occur to me. If what he is telling me is relevant to the case we've got before us. To me it's just evidence."

For this group the essential characteristic of the evidence presented to them, whether from a scientist, a technologist, or anyone else for that matter, was the expert nature of that evidence. This idea of expert evidence is important for technology educators. For the effective implementation of any technological development, the technologist must be able to communicate the essence of that development and persuade the relevant decision maker to invest in or approve of it. In a legal framework, that may mean that technologists will be required to proffer expert opinion evidence so that the decision maker or court can make an informed decision. Whether those outside technology education perceive technology or technologists to have a commonality of purpose or method that is different to science is not at issue. Clearly, there are a range of views and many of those prominent in decision making in our societies will have very different views from each other as well as from technology and science educators. However, within the courtroom framework there are some consistent themes that educators should address to ensure that technology students are appropriately prepared for possible future roles as experts.

Characteristics of a "Good" Expert Witness

Independent Evidence

When asked what were the characteristics of good expert witnesses there were some common themes identified by all interviewees as being essential. The most common, which was mentioned by all interviewees, was the requirement that experts, whether classified by the interviewee as a scientific expert or not, should be independent of the parties, but should proffer their opinion to the court objectively and without appearing to advocate for the instructing party in any way. Many interviewees noted that the duty of the expert is to inform the court using their own expert opinion, and the appearance of bias or advocacy was the most commonly described indicator of a "poor" witness.

The appearance of any advocacy or bias on the part of an expert witness could result in his or her evidence carrying considerably less weight, or being completely ignored.

Some interviewees also noted that while the lack of objectivity would damage an expert's credibility, the ability to concede a point would enhance that credibility. One judge described the characteristics of a good expert as follows: "A person who is prepared to concede a point. That's number one. You can pretty well pick... the expert who is going to dig his heels in and no way is he going to shift and that guy is useless..."

This reference to concession of a point was repeated by several interviewees as an indicator of an objective witness—possibly because to do so is almost antithetical to advocacy. However, and more seriously, if the worth of an expert's testimony is judged by how objective, in a non-partisan sense, the expert is, then experts should be taught how to communicate their evidence accordingly.

Presentation

Another common theme among descriptions of good expert witnesses was the depth of understanding experts had for a particular situation and their ability to effectively communicate their evidence. In some situations effective communication may mean an interesting oral presentation. One commissioner commented:

...we do have some expert witnesses who...and it is not about their evidence... but they are boring and their voice is hard to listen to. ...the best ones are the ones that have a passion and they really believe in what they are on about and that is what they are presenting...and they are clear.

It was also important for the interviewees that experts were able to give their evidence in nonjargon language so as to "educate and inform the court." In some cases the interviewees preferred experts to use everyday analogies as part of their explanations and to use clear and simple diagrams and charts. This ability to clearly explain their evidence was also seen as an indicator of the expert's own knowl-

edge and understanding.

Personally, if a technical person or a scientist can't explain anything in terms that the person you are speaking to can understand, then I doubt whether they can understand it themselves, in that, they are just parroting terms that they acquired in their studies. Whereas if they really understand it they can explain, at least to an adequate extent. [Commissioner]

This ability to explain issues in language accessible to the lay members of the court does have its limitations, however. One interviewee commented that an expert should not appear to "talk down" to the members of the court or to give the impression that his or her evidence was necessarily superior to that of other experts. Likewise, the clarity and conciseness of evidence was seen by some members of the court to be relative to the type of expert. Those experts perceived to be scientific might have to give longer and more detailed evidence.

Qualifications

When asked how the court measures the expertise of an expert witness, the most common response related to the expert's qualifications and also his or her list of previous publications. The importance of qualifications to some members of the court is particularly evident in the following comment from a commissioner who was describing the process for deciding between several different experts giving evidence on the same subject matter:

...we find out their commonality of agreement and where they disagree, highlight that...then you will line up the qualifications of the respective experts and that is what we go with. So if one has got an extra degree from Oxford, or something else from Cambridge, or whatever.

A judge also emphasized the importance of publications for the assessment of the credibility of scientific witnesses: "...a scientist has published papers. ...the fact that they've published papers in their curriculum vitae...is an important part of their evidence, because they have to qualify themselves as experts."

Given the scope of evidence perceived to be scientific, this latter requirement may be significant for many technical experts because they may not routinely produce articles for publication as part of their professional practice. Such witnesses would have to establish their expertise in other ways, such as giving details of their duration of professional practice or of experience with similar matters to the proceedings before the court.

Expectations Regarding Methodology

When asked how expert witnesses obtained the substance of their evidence, there was no apparent pattern to the requirements for good practice. Some members strongly insisted that an expert must have personally obtained the substance of his or her evidence from measurement of data. Several commissioners commented that they had been personally admonished in court when in their earlier working lives they had appeared as expert witnesses and had proffered evidence that was not obtained under their direct supervision. Other interviewees accepted that in certain situations an expert may have sent an assistant to obtain the raw data but must have performed the analysis him or herself. This practice was commonly acknowledged in respect of acoustic engineers who may take noise measurements at intervals throughout the day and night. Some members were adamant that evidence could not be based on analysis of a literature search because the expert had no direct knowledge of the subject matter. This requirement is linked to common law rules concerning the admissibility of expert evidence, although these rules are not binding on the environment court (Freckleton & Selby, 1993). For other members, however, not only would a thorough analysis of literature be acceptable, but also an analysis of data proffered by an expert engaged by the opposing party. This diversity of expectation is worrying because there is no obvious way that a given expert could appreciate the requirements of the court regarding the expert's methodology. In addition, criticisms about methodology were not only leveled at newer experts. Sometimes very experienced experts were criticized for presenting their evidence in the same way that they had always done but with less personal involvement in the

collection of their evidence than another expert in the same field. In respect of methodology, it is clearly necessary that the court develops its own consistent policy, but that policy should be informed by the members of the various professional groups that represent scientific and technical experts. In turn, technology and science educators have a role in grounding students in sound research methods and practices and in contributing to the continuing education of those people who are outside the technology or science communities but who encounter the personnel and subject matter from those communities on a regular basis.

Implications for Technology Education

The preparation and presentation of an expert opinion is an important and common aspect of the working life of many technologists. It is natural that decision makers in a range of different arenas will require expert technical advice concerning a multitude of different proposals and issues. I suggest that educators should have a role in preparing students to face a variety of situations in which their expert opinion will be under scrutiny. This view was also expressed by several members of the environment court as follows: "...the new, young planner straight from graduate school... isn't fully given to understand what is his or her role, and the failure is on the part of graduate schools." [Commissioner]

Technology education must emphasize the importance of effective communication at two different levels. First, students of technology need to recognize the importance of communication during all stages of their development. Effective communication requires recognition of the expectations of the intended audience (Nelkin, 1996). For many students of technology that audience may at times be a court of law. Although the environment court has differences in its expectations of experts, the qualities of independence, clarity, and depth of understanding were approved by all interviewees. Those qualities could easily be incorporated into technology education by encouraging students to present interactive seminars to explain their work. The notion of independent expertise could be developed by having students present interactive seminars based on each other's work. The notion of an interactive

seminar would promote the need for clarity, consistency, and depth of understanding, which were all valued qualities of expert witnesses.

At a second level, there is a role for technology educators to provide continuing education to those lay people who regularly assess information provided to them by experts. These lay people may be members of a legal forum such as the environment court or they may be members of local authorities, governmental organizations, or other decision-making bodies. While my research has focused on a relatively small court in New Zealand, it is likely that these results will be transferable to other courts and other countries. The environment court hears a lot of very technical evidence, and its specialist nature is part of the reason for a combined legal and lay composition. Thus decision-making bodies that are constituted without any specialist technical expertise are likely to be less familiar with the framework and methods of technology as a curriculum component. Most of these people will not have had the benefit of any technology education and their views will reflect their own personal educational and practical experiences. It is likely that they will use language in different ways to each other and may view the role and

experience of the experts who proffer advice quite differently from each other and from the experts. Thus, there is a role for technology educators to work with decision makers to develop appropriate criteria for assessing expert opinion evidence and to communicate the goals and methods of technology studies as distinct from science and other educational frameworks that may be familiar to those decision makers.

Modern legal decision makers regularly hear a large amount of expert evidence from a wide range of disciplines and in relation to a wide range of issues, including environmental, criminal, and commercial matters. Many of those experts proffer technical evidence that concerns aspects of design, manufacture, and use of technological developments. It will be a serious flaw in technology education if that evidence is not successfully communicated in the legal environment because of a mismatch between the expectations of decision makers with those of expert witnesses.

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Recruitment Strategies for Industrial Technology Programs

Ron O'Meara and Mindy Carmichael

Introduction

Today's competitive marketplace requires many colleges and universities to search for ways to maintain or increase their program enrollment numbers. One method is to focus on an enrollment management program with an emphasis placed on retention efforts for existing students. Although this is one important issue facing many colleges and universities, it is not the only method for maintaining or enhancing enrollment figures. The need is to focus on both retention efforts as well as the recruitment of prospective students to provide the foundation to build enrollment numbers.

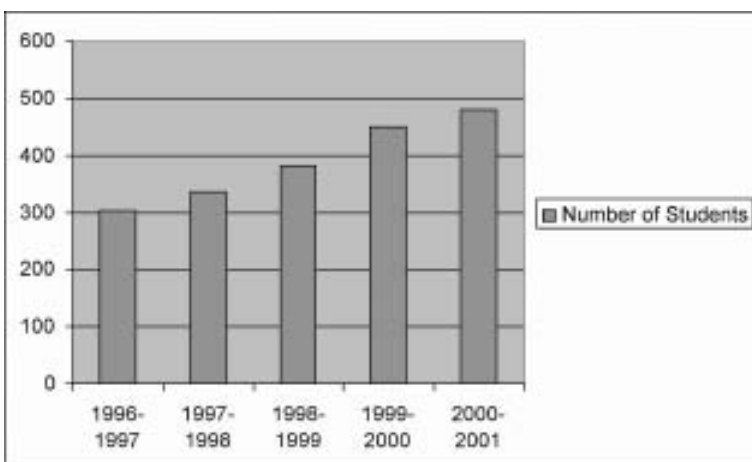
Competition in starting salaries of graduates from business and/or engineering programs can make it challenging to recruit students into industrial technology programs. Further, it is predicted that as technology continues changing at a rapid pace the new jobs created will require additional education (Brandon, 1997). Coupled with this are projections of a shrinking labor supply and increased competition among educators for their respective programs. The interest in the field of industrial technology is evident, but it is imperative to make students aware of both industrial technology programs and career opportunities. Educators need to be proactive in recruiting students to meet society's increasing employment needs and for maintaining or strengthening their enrollment numbers and even more so ensure the quality of the students.

In order to meet the challenging demands of student recruitment, industrial technology educators must leverage their recruitment strategies that specifically highlight industrial technology disciplines. The general focus of this article is to share a broad overview of several recruitment strategies that have proven effective at a regional university located in the Midwest.

Departmental Enrollment

Enrollment in the Department of Industrial Technology at the University of Northern Iowa has increased at a steady rate over a five-year period. With a growth of 62.7% in five years, the department has gone from 295 majors in 1996 to 480 majors in 2001 (see Figure 1). With 97% of the 13,533 students enrolled in the university coming from Iowa high schools and community colleges, the enrollment increase is due in part to recruiting efforts from these educational institutions. A strategic recruitment plan was designed to generate students and gradually increase enrollment over a five-year period. The strategic plan was successful, and the increase in enrollment resulted from four different reasons: (a) an increasing number of incoming freshmen to the university, (b) transfer students from two-year programs, (c) an on-going recruitment effort by a full-time recruitment coordinator, and (d) the efforts of faculty, staff, and current students.

Figure 1. Enrollment increases in Department of Industrial Technology at University of Northern Iowa.



According to Zargari, Devier, and Schumm (1999), comprehensive transfer agreements between community colleges and universities need to be established to increase student enrollment. Administrators at two- and four-year institutions seeking articulation agreements can benefit through improved student retention rates and cost savings (McDuffie & Stevenson, 1995; Wattenbarger & Witt, 1995). One of the most important reasons for developing articulation agreements is to improve access by giving students more options and smoothed pathways to achieving degree completion (Bryant, 2001). The Department of Industrial Technology realizes the benefits of this partnership, and articulation agreements have been and will continue to be a vital asset to the enrollment increase in the department. In 1998 the Department of Industrial Technology created and approved 60 articulation agreements with Iowa community colleges. Three years later the department had a total of 317 different articulation agreements with all 15 of Iowa's community colleges. The university has a different agreement with almost every associate of applied science degree at the various community colleges in the state. In 1999, the university had a total of 1,114 transfer students with nearly 70% coming from Iowa two-year colleges (Carlson & Wyatt, 1999). Of the 1,114 transfer students, the Department of Industrial Technology had 58 students transfer into its programs in 1999-2000. Further, during the academic year 2001-2002, the number of transfer students increased to 76, and by the academic year 2003-2004, the transfer students increased to 114. The university expects to see additional increases in students transferring from Iowa community colleges as more departments generate articulation agreements for their programs.

Enrollment Trends

To examine the enrollment trends of industrial technology programs within the state of Iowa, data contained in the *Industrial Teacher Education Directories* (Bell, 1997, 1998, 1999) were analyzed. The three-year period reviewed for this analysis is reflective of the University of Northern Iowa's departmental recruitment plan that was initiated in 1996. Edmunds (1990) established that the use of directories is germane

for quantitative analysis of such programs. The data reviewed are aggregate numbers for the state during the three respective years of the initiated marketing study. The aggregate numbers were compiled to use as a baseline for comparing the enrollment growth at the University of Northern Iowa to the growth in the industrial technology program at Iowa State University.

Based on the data reported in the *Industrial Teacher Education Directories* from 1996 to 1999, enrollment growth of industrial technology programs in Iowa experienced an increase of 11.6%. In 1997, the total number of degrees granted from four-year institutions having the degree discipline of industrial technology or technology education was 172. The number of degrees granted in 1998 was 169, and in 1999 the number increased to 192. It is important to note that these aggregate numbers represent all degrees granted in the disciplines including bachelor's, master's, and doctoral degrees.

There are limitations when using secondary data for analyzing trends in enrollment figures. However, this analysis was performed to establish a baseline for comparison of growth in industrial technology programs statewide as compared to departmental initiatives. It is worth noting that the growth in industrial technology programs appears to have occurred across all emphases within the discipline.

Recruitment

Educational institutions have many strategies for recruiting students, but awareness of the program seems to be a key factor for industrial technology. When the department designed its recruitment plan in 1996, a vast span of recruitment programs was created to either bring students to the Department of Industrial Technology or to take industrial technology program information to them. After initial attempts in recruiting, the department focused on bringing prospective students on campus to highlight the department and programs. The plan has proven effective and enrollment has continued to increase.

One of the department's largest recruiting tools is the Industrial Technology Day. For one day each semester, the department brings in

about 125 students from Iowa's high schools and community colleges to view the department, receive program information, and gain hands-on experience. During this half-day event, students are able to see what industrial technology has to offer both from an educational and career opportunities standpoint. The sessions relate to the nine different emphasis areas to major in within the department, of which students can select three to participate in. A breakdown of student participants from a recent IT Day is shown in Figure 2. Faculty, staff, and college students coordinate the sessions and design them so the IT Day participants can view a variety of areas within the major. At the end of the day, questionnaires are given to each student for an evaluation and comments concerning the IT Day. The responses have been positive with students commenting on the benefits of the hands-on experience, viewing the labs, and being able to work directly with faculty, staff, and college students. They also appreciated working on and designing a project and having something to take home with them. This day has been an effective method in recruiting students by bringing them to campus to consider the department and learn the benefits of choosing a major area of emphasis in industrial technology.

Survey of Impact

A multimedia recruitment survey was compiled in the spring of 1999 and sent to Iowa's 420 high schools and 17 community colleges. Guidance counselors were asked about video, CD-ROM, and Internet use by students to

acquire college and career information. When asked about videotape usage, 73% surveyed stated that their students use videos for this purpose, whereas 68% used CD-ROMs for college and career information. Internet use is the most effective tool; 96% of the counselors surveyed acknowledged this usage for their students because of easy access and availability.

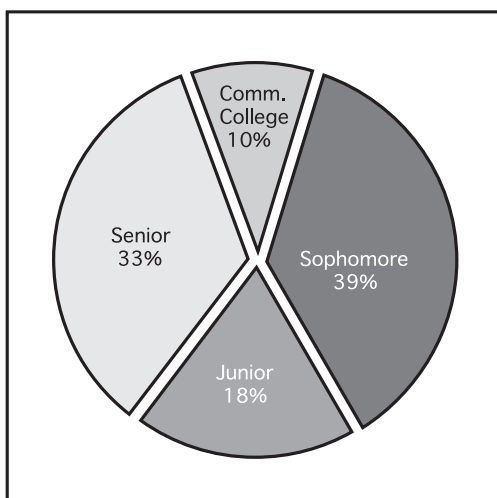
This survey helped to determine future recruitment tactics and proved the Department of Industrial Technology's hands-on method of recruiting highly effective in attaining our recruitment goals. Although schools suggested that students use the multimedia references, they still prefer to go to the college or job site for information. Before our recruitment push took place, videos were sent to requesting high schools and community colleges, but feedback was never received concerning interested students. However, when recruiting efforts started to bring students to campus, responses were positive and enrollment also increased. The multimedia survey was done to help determine if changes needed to be made on the recruitment strategy after four years or if the plan was still on track. Although the hands-on method of recruiting has been valuable, there are additional tactics utilized to strengthen the department's goal.

Scholarships are an important emphasis in our recruitment plan. The Department of Industrial Technology gives more than 35 scholarships yearly to freshman, sophomore, junior, and senior students. Many of these scholarships are full tuition and are used to recruit students and to reward current students. Other areas of importance relating to the recruitment goals are student organizations, high school outreach programs, the NAIT interactive CD-ROM, exhibitions at conferences, and advertising in magazines.

Conclusion

There are many aspects impacting enrollment figures at the start of the 21st century. The tightening labor supply, new workplace skills, and increases in starting salaries for shortage areas influence students' choice of programs and the resulting enrollment numbers.

Figure 2. Student breakdown for IT Day, Spring 2000.



Enrollment figures for the state of Iowa are growing at a nominal rate within the field of industrial technology. The growth for the state during the period of this study was 14.2%. As a comparison, the growth realized at the University of Northern Iowa for the same period after implementing a strategic marketing plan was 62.7%. This increase in enrollment is a positive indicator of program viability and a strong commitment to a systematic marketing design.

To maintain existing enrollment figures and increase future enrollment numbers, educators will need to cast a wide net utilizing a cross-discipline marketing strategy. A commitment to perform continuous recruiting to provide growth

in enrollment figures and fully utilizing the resources at hand (i.e., faculty, staff, advisory boards, recent industrial technology graduates) is a key component of a successful recruitment strategy.

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Is the Serpent Eating Its Tail? The Digital Divide and African Americans

Jacqueline Horton

The Internet is getting larger every day. Computers, through the Internet, are becoming a significant part of our everyday lives. More and more companies and organizations are using the Net to inform, educate, and entertain. As we travel the Information Highway, a growing number of the phases of our lives—identification, money, security—are being handled electronically.

The Digital Divide is alive and well in America. What this means is the technology haves and the have-nots are continually growing further apart. Due to the pace of change in the field of computer technology, this divide widens faster in less time. Playing catch-up becomes an increasingly more difficult game to endure, with the government, public, and private sectors trying to invent ways to level the playing field. However, according to the U.S. Commerce Department's National Telecommunications and Information Administration's (NTIA, 1999) paper "Falling Through the Net III: Defining the Digital Divide," many of those who are left behind (Blacks, Hispanics, Native Americans, those with education below the high school level, single parent families, those with income less than \$25,000/year) are trying to catch up themselves by accessing computers in community centers and libraries. Since parties on one end of the Digital Divide are using computers to get themselves to the other end, why aren't more online?

The purpose of this study is to look at racial overtones to Internet access. It is assumed that it is important to have both computer and Internet access to compete in both school and work. By looking at how the Web is being used, ways can be suggested to make computer access

easier and more convenient for African Americans, thereby increasing their interest in computer technology and information.

What follows is a discussion on content and the Internet. While cost is the dominant reason for discontinuance of online service, lack of interest ("don't want it") is the number one reason for not having Internet access at home (NTIA, 1999). If individuals can't perceive the importance of an object or how it could affect their lives, they will not go out of their way to try to learn to use it, or excel at its application.

History of the Internet

Technology can indeed act as prosthetic extension of human powers and communities. (Brook & Boal, 1995, p. vii)

Welcome to the Information Age. The Information Age began when people turned their minds from using machines to manufacture goods to using machines to process information. Productivity in the Information Age is not due to more workers or longer assembly lines but to informed teams and smarter modes of work (Carnoy, Castells, Cohen, & Cardoso, 1993).

Because the Information Age is relatively new and has spawned a tremendous rise in, particularly, scientific information, I suggest that the Information Age began in 1968 with the formation of the ARPANET (Advanced Research Projects Agency - net), the Internet's predecessor (Zakon, 1993-1999), developed by the U.S. Department of Defense. The development of the ARPANET necessitated the creation of packet switching technology and the different but compatible platforms from which it would need to run consistently and reliably, important concepts on which today's Internet is based.

ARPANET and e-mail were first demonstrated publicly in 1972 (Zakon, 1993-1999). The Domain Name System (i.e., SFSU.edu) was introduced in 1984 (Zakon, 1993-1999). In 1991, the World Wide Web was introduced, and the NSFNET backbone was upgraded to T3 (44.736 mbps) and passed 10 billion packets per month (Zakon, 1993-1999). Ten billion packets at 44.736 mbps is a lot of information moving very fast.

A Brief History of the Effects of Technology

In any case, for millions across the globe, there is no private phone, fax, or TV, let alone a computer or an automobile. *And there never will be.* This is not a question of progress or modernity delayed. (Brook & Boal, 1995, p. 11)

Obviously everyone is not keeping up with this increased flow of information. In 1994 the NTIA reported that while 27.1% of Whites had computers in their homes, only 10.3% of Blacks and 12.3% of Hispanics owned computers (NTIA, 1999). In 1998, four years later, the number of households with computers doubled for everyone; but in comparison with Whites, Blacks and Hispanics were even less likely to have household access to computers (46.6%, 23.2%, and 25.2%, respectively; NTIA, 1999). In fact, “Whites have more access to computers in the home than Blacks or Hispanics do from any location” (NTIA, 1999, p. xv). In 2000, 36% of Blacks had access to the Internet, in comparison to 50% of Whites who had access. While the difference between the two groups is getting smaller, it does not appear as if everyone will arrive in this Information Age at the same time (Spooner & Rainie, 2000).

Is this Digital Divide an anomaly, an unlikely case of an egalitarian product that exacerbates class struggles? Or is the Internet simply the product that affects us today, a system whose consequences are even more dramatic due to this 21st century globalization that we are experiencing? Several writers have noted that African Americans have routinely gotten the short end of the technology stick with computers and that the Internet is at the end of a long line of “firewalls” built to keep Blacks out.

One of the first major technological inventions to adversely affect African Americans was Eli Whitney's cotton gin. Whitney's gin allowed cotton to become an easy and cheap commodity.

Because more slaves were needed to aid in this new growing industry (Walton, 1999), there was a huge jump in the slave trade. The year 1865 saw the end of the Civil War and the beginning of the Reconstruction. African Americans were free technically, but being penniless and landless in an agrarian society, could not be economically or even physically emancipated. Most Blacks were uneducated after experiencing 200 years of slavery. What was the use of freedom without education? Not much. It would be akin to being given a boat with no oars. Blacks needed other avenues for growth. Slowly but surely they made gains in areas other than farming, where they had previously had the most experience.

After the Civil War, Blacks began the migration to the North. The Industrial Revolution spurred the need for many more industrial workers, and Blacks were allowed to fill the void—some in semi-skilled jobs but most in unskilled, domestic, and janitorial jobs in both the North and the South (Marshall, 1967). Automation in the late 19th century to early 20th century increased mechanization, which allowed more Blacks to be employed in jobs that previously required training and experience (Harris, 1982). Technology at this point helped Blacks in the workforce. The migration of Blacks to the North helped make up for the staunch immigrant labor pool during World War I.

The National Recovery Act of 1933 was an attack on urban poverty. This act shortened the workweek and instituted minimum wages for occupations. But instead of offering Blacks and Whites the same wage for the same work, employers classified the jobs differently, which allowed professions that were heavily worked by Blacks to be classified at a lower level or to be exempt from classification altogether (Marshall, 1967).

By the early 1940s African Americans, despite setbacks and opposition, had doubled their numbers as skilled craftsmen (Harris, 1982). The increase in the diversification of jobs continued at this time leading to a general increase in the number of African Americans employed. Unfortunately, 80% of the Black male working population still worked in jobs considered unskilled (Harris, 1982).

World War II saw further increases in the Northern migration and employment of Blacks. The number of Blacks employed in semi-skilled jobs grew, mainly because of the monies pumped

into the war effort and the drafting of White workers into the armed forces, which depleted the growing workforce (Marshall, 1967). Even so, Blacks were not given adequate chances in training programs and new jobs.

Negroes have faced a more serious unemployment problem than white workers throughout the postwar; the jobless rate for Negro workers has remained about twice that of white men and women since the early 1950s. The ratio persists at each level of educational attainment, with the differential even greater among workers with more schooling than among those with a minimal level of education. (Harris, 1982, p. 123)

In the 1960s job opportunities did not improve much for the Black male. Black gains in the 1950s were in semi-skilled jobs. However, when automation replaced semi-skilled workers in the 1960s, their employment declined to the level achieved in 1948 (Harris, 1982). Mechanical cotton pickers were used increasingly, which caused further unemployment among Blacks still living on Southern farms (Harris, 1982). Blacks were able to make gains in securing professional employment with the federal government, however. Even so, in 1961 72% of the lower ranked jobs (grades GS 1-4) were held by Blacks, while 35% of all employees were employed in those levels.

Technology increased in the 1970s and 1980s, and the economy shifted from manufacturing to low-paying and service-oriented jobs (Harris, 1982). The accompanying decline in the numbers of low-skilled manufacturing jobs did not help the standard of living for Blacks. "The socioeconomic status of Blacks was as depressed in 1980 as it had been in 1969" (Harris, 1982, p. 179).

And now in the 21st century, we have computers and the Information Age. How prepared and how well positioned is the average African American to move on the Information Highway?

The Digital Divide

More than 100 million people around the world, most of whom had never heard of the Internet four years ago, now use it to do research, send e-mail to friends, make requests for bids to suppliers, and shop for cars and books. (U.S. Department of Commerce, 1998, p. 4)

While the Internet is thought to be an equalizer, it has never been thought of as a level playing field. Black entrepreneurs make the play, gaining footholds (Muhammad, 1999). Most of the Black Internet/computer users are between 24 and 48 years old and make more than \$40,000 (Hoffman & Novak, 1999). Though the numbers appear more egalitarian for Whites, they are still linked strongly to household income and education. The higher the income and education, the greater is the chance that a person will own or use a computer.

In the United States, the person who doesn't own a computer is more likely to be a person of color with little income and education. He or she will more than likely be either single or a single parent and live in the inner city or a rural area. If there were no Digital Divide, so accurate a picture of the have-not world could not be painted. But study after study shows the above to be the case.

You can't have the Digital Divide without the Digital, but is the Internet at fault? Remember that the Internet was not made for everyone to use but developed by the Department of Defense. Perhaps it has problems scaling up for general use. While technology can be seen as morally neutral, it cannot be assumed that the uses to which it is put are equally sanguine.

These uses seem to be either of no use or of no interest to most people. This creates an information disconnect, an information divide. This information divide is what is fueling the Digital Divide.

But the flight into cyberspace is motivated by some of the same fears and longings as the flight to the suburbs: it is another "white flight." (Brook & Boal, 1995, p.ix)

If the Internet is truly blind ("No one knows if you are a dog on the Internet" [Steiner, 1993, p. 61]), why isn't everyone on it equally? There are so many variables (education, income, age) to the information have-nots when you look at African Americans that it is hard to get a clear picture of what is happening and why, and what to then do about it. Let's look at the education variable for example. While this article does not focus on the effect of education on the Digital Divide, it should be noted that it mirrors the Educational Divide as it pertains to

Blacks who are, once again, on the wrong side of the line. It is no secret that Blacks and other minorities do not receive the best educations, particularly if they attend an urban school (Rist, 2000; Temple, 1998). It is the same forces at work in the Digital Divide as in the Educational Divide. Large class sizes and crumbling institutions, which characterize the urban public school to which many minority and poor students are sent, are but the physical harbingers of the differential yet lasting treatment afforded to people of color (Temple, 1998). All of these factors work together. How else do you explain the inability of Black high school dropouts to be employed at the same rate as White high school dropouts (Marshall, 1967)? There are many facets to the Black economy, and education is one of them; so is knowledge and manipulation of things digital. The idea here is to focus the issue of the Digital Divide on race in hopes that it will focus attention on all race-related items such as education and income and that the digital tide will aid in floating all such boats for African Americans.

Focusing on employment, do African Americans have jobs that do not require a computer and so are never exposed to one? Do they not go grocery shopping or use an ATM or go to the library? The sad fact is that if you are Black, you are more likely to live in an inner city, drop out of school, and earn a low income (Bolt & Crawford, 2000; Harris, 1982). So is the Digital Divide racial or is it education / income based? These items are so closely intertwined for African Americans that you cannot say either way. What we can do is take a look at what African Americans do when they are online. Perhaps this will shed some light as to why they are not online in greater numbers.

African Americans use the Net for online classes and job hunting (Hoffman & Novak, 1999; NTIA, 1999). African Americans shop online just like everyone else, but they do not search for product information as much as others (Hoffman & Novak, 1999).

So now we have a better idea, though not complete by any means, of what Blacks do online. It sounds like they know how to put the computer to good use, so why aren't they online more? Three suggestions: exposure, cost, and content.

Exposure

In 1999, Tom Joyner and Tavi Smiley threatened to sue CompUSA to get the retail giant to place ads with African American-oriented media (Associated Press, 1999; Wickham, 1999). Digital technology is not so abundant in the inner city as elsewhere. Schools are considered wired when they have one computer hooked up to the Internet; schools in wealthier areas have more computers hooked up to the Internet per student than those in poorer neighborhoods (Bolt & Crawford, 2000; Goslee, 1998).

Cost

While computers are coming down in price, it is the webTV versions that are readily available for under \$500. Otherwise, a quick perusal of newspaper ads shows most computers to be still at the \$1,000 mark (monitor not included). Computers are also a lump sum purchase, which is a large amount of money to pay all at once for an item with questionable usage and value. Then there are the monthly ISP fees to add to the expense.

Content

While there are hundreds of thousands of Web sites on the Net, there are only a few hundred of special interest to African Americans (Bolt & Crawford, 2000; Hoffman & Novak, 1999). But do you have to have Black-specific content in order to get African Americans online? Aren't they cat lovers and stock buyers and music aficionados as well? Perhaps what African Americans need in order to get on the Net is a "killer app" (a software program that drives up sales of computers)—e-mail isn't it and mp3 isn't it. What will it take to get African Americans to see that the digital life is useful for them?

Again, the three possible reasons for African American involvement on the wrong side of the Divide are exposure, cost, and content. Content will be further explored next.

Content and City.net

Despite the strong demand for labor, many workers are failing to realize the benefits of California's economic boom. (Yelin, 2000, p. 1)

There are many ways to bypass the cost issue. The U.S. government is doing its part in the reduction of the cost of computer equipment and hookups to the Internet. An E-rate

(NTIA, 1999) has been implemented that ensures discounted connection rates for schools and libraries, thus enabling more public schools to get wired. In addition, President Clinton's "Call to Action for American Education" allowed for all public schools and libraries in the U.S. to be wired for technology by the year 2000 (Novak & Hoffman, 1998). The other half of Clinton's "Call to Action" is to connect every U.S. home by 2007 (Novak & Hoffman, 1998).

Between the E-rate and the "Call to Action," most of our nation's children have access to computers. Free PCs given out by Internet service providers and subsidized PCs given out by employers presumably take care of any other cost concerns on the part of nonwired African Americans everywhere (Thierer, 2000).

What is more, computer prices are dropping. Some color TVs cost more than computers, and yet people still buy them (Thierer, 2000). Computers and other Internet technology will get steadily cheaper and cheaper until the issue of cost simply fades away.

Clinton's "Call to Action" will have every public school child exposed to the Internet. They will go home and spread the "tech-virus" to their siblings and other family members they come in contact with. Also, adults without access to children are working in places that are getting wired, exposing more adults to the technological wonders.

As more people buy computers, computer makers and retailers will have to consider seriously the untapped market of the unwired: the low-income, rural or inner-city dwelling minority. The unwired are ripe for saturated exposure through advertising.

What is more, government entities will increasingly put more information on the Internet. Therefore, people who require up-to-date knowledge of benefits, such as disability or Social Security, will find this information being put online more often in the future (U.S. Internet Council & International Technology and Trade Associates [USIC & ITTA], 2000). People will be forced to look to the Web for information that has a direct impact on their lives. In time, the exposure for African Americans will increase, slower than their ability to gain access, but it will increase all the same.

Content is the final piece of the puzzle.

Content is what will make people take their first steps onto the Internet and will make them stay online once they try it. Content is what is going to prepare America for the new "digital workforce" as described by the U.S. Department of Commerce. Increased interest will come from more significant content. Enlarged interest will reduce fear and allow Black people to take ownership of things digital (U.S. Department of Commerce, 1998).

But what content is needed to lure African Americans across the Digital Divide? As with any design problem, the best way to find out why the customer is not buying the product is to listen to the customer talk about the product. So one must either ask users directly or observe them during use (or nonuse as the case may be). This article does not contain results of interviews with African Americans nor does its author claim to have looked over the shoulders of African Americans while they used a computer or passed a computer store; that would be grist for a whole other article. However, from what has been read and researched about the Digital Divide and African American computer use, or lack thereof, I have come up with what might be an answer to the content question.

Access and exposure are good, but those two conditions do not make one computer literate. In *Newsweek* magazine, Alter (1999) stated that, in addition to having access to the Internet, people must use their creativity and initiative to get the most out of the computer. Being superficially introduced to the Internet or insufficiently exposed to software will not be enough to make one computer literate. The Digital Divide is not just about access; it is about what people do with a computer once they have one.

In *Digital Divide: Computers and Our Children's Lives* (Bolt & Crawford, 2000), B. Keith Fulton, director of Technology Programs and Policy with the National Urban League said, "In the Information Age, it is critically important to master the three basics: reading, writing and arithmetic...but also to have information literacy: the ability to access, interpret, and respond to information" (p. 114). Once again, access is important; but in our future and the future of the world, we cannot afford to leave anyone behind. Everyone should become acquainted with this information literacy. People should be unafraid to approach

technology and should have a general idea as to what can be done with it.

New studies suggest much the same thing—content is the way to get people online. The Digital Divide Network (2000), quoting the recent Stanford University (2000) study and National Public Radio (1999) study, stated that the Internet technology industry is building networks for users as consumers but not for people who want to make content themselves. The Children's Partnership's March 2000 report on online content suggested that people, in particular those with low incomes, would prefer to have local information on the Web. Items people would like to see more frequently are employment, educational opportunities, and business development prospects. The importance of producing content was also brought up by the Digital Divide Network (Lazarus & Mora, 2000; Twist, 2000). Even the U.S. Internet Council's (USIC & ITTA, 2000) "State of the Internet 2000" paper discussed the growth of "virtual communities" (p. 22). These virtual communities have local information and have grown from simple chat rooms to Web portals with news, weather, e-mail, and the like.

So even content is not a simple matter of just giving it away. People want information that is useful to them. If people don't want to go on the Internet, it is because the information is not useful and because it is hard to find and navigate. But if people make their own content, then it is as interesting and as easy to navigate as they make it (Goslee, 1998; Lenhart, 2000; National Public Radio, 1999).

My idea to closing the Digital Divide for African Americans is City.net, a portal where the residents create and edit the Web site. For example: San Francisco, California, has several different neighborhoods. Each neighborhood has its own character, its own main street, its own cultural flavor. Each neighborhood would have a Web site where each resident would have a login, e-mail if necessary, and access to the citywide portal. After being given computers, hookups, software, and training provided by a tech-savvy nonprofit, the neighborhood would have a technical town hall meeting where the design of the neighborhood's Web site would be created and decided upon. So, as an example: Chris Johnson, resident of Bayview would have an e-mail address of cjohnson@bayview.sf.net. This e-mail would allow access to Bayview's

site as well as any sf.net neighborhood's site. Chris also would be able, as a resident of bayview.sf.net, to add information to the neighborhood's site. Job availability, health risks, education opportunities in the near vicinity could all be posted on the appropriate neighborhood page. Chris could query neighbors about what classes or information they would be interested in and then they could arrange to have a class or speaker come and give a talk on that subject at the neighborhood center. The Web sites would be picture (graphic) heavy in order to make them easy to navigate and understand. The neighborhood could then have pages translated or even written in languages other than English based on the needs of the neighborhood.

How would people without much computer literacy (or whom may even be illiterate) be able to post things on City.net? Once format is developed, pages could be formatted so that adding information should be a matter of point-and-clicking or typing the information in. Important citywide announcements could then be broadcast to all residents. Federal and state information could also be given out in this way. But everyone must be involved or the City.net will not represent all of its people.

The City.net has been tested in other locales. It was documented in the Children's Partnership's *On-Line Content* (Lazarus & Mora, 2000) paper. Brooklyn, in New York, and Chicago's www.northwest.com are two examples of online community resources that base their content on the values and input of their neighborhoods (Anderson, Bikson, Law, & Mitchell, 1999; Lazarus & Mora, 2000; Schön, Sanyal, & Mitchell, 1999). While these virtual communities are like the City.net introduced above, the scale is smaller and the participation of all citizens is not as inclusive. That said, these online community resources have the capability of increasing interest in the Internet and other digital technologies for those who have been previously disenfranchised. City.net and like portals could be the "killer app" the Internet is waiting for.

In conclusion, one can hope that the Digital Divide will disappear as a result of the decrease in prices for computers and the increase in alternate methods of accessing the Internet. But content is the last key to the puzzle. Content will draw those not previously interested into the

fray. City.net, a portal that would combine home computer ownership with software training in order to have residents build a neighborhood's personalized site, is my idea to increase the African American presence on the Web.

Conclusion

The Gartner Report on the Digital Divide (Smolenski, 2000) posited a three-stage Digital Divide in America: Stage One is lack of computer access; Stage Two is lack of experience with technology, which limits the use of important information and sites away from disadvantaged Americans; and Stage Three is lack of broadband access to the Internet. Throughout this article I have suggested three stages as well. The first stage is lack of computer access. The second stage of the Digital Divide is lack of access to the Internet (the first and second stages are sometimes addressed concurrently), and the third stage is lack of expertise. Expertise is the equivalent to Gartner's second stage of experience. However, expertise for this article not only includes experience with the Web and the Net, but with all digital things. The further development of information literacy is the reason that closing the Digital Divide is so important. The Digital Divide is not an issue simply because people do not have access to computers or the Internet; it is an issue because this lack of access breeds an unfamiliarity with the digital technology and information revolution that is so pervasive and necessary here at the turn of the century and beyond.

For African Americans the effects of this third stage of the Digital Divide is real. Blacks are less likely to have a computer in the home (NTIA, 1999). While they may be getting wired in record numbers, they are more likely to be new to computers and the Net, and therefore forever behind the experience curve (Spooner & Rainie, 2000). A whole generation will be too old for the wiring of the schools and too young to have been in the first wave of computer use. These people don't disappear. They move through their lives just a little bit behind everyone else. African Americans need a program that will jump start them and propel them quickly to the level of, if not beyond, their White and Asian counterparts. African Americans do not have time to wait for computers to get cheaper or schools to be wired or Net content to realize their worth as consumers. A program such as City.net, which would provide for training, access, and content production in a concrete package, driven by private industry and managed by nonprofits and the citizens themselves, would go a long way towards dismantling the Digital Divide.

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Student Perceptions of Web-Based Supplemental Instruction

Steven A. Freeman and Dennis W. Field

Introduction

Nearly every university and college in North America now has a Web presence (Saba, 1998). Approximately 70% of U.S. colleges and universities provide undergraduate applications online and nearly 77% provide their course catalogs online (The Campus Computing Project, 1999). The Internet is also changing the way in which education is delivered, and in fact, some predict that the Internet will become the dominant distribution system for distance education and training (Simonson, Smaldino, Albright, & Zvacek, 1999). Many faculty members are expanding their traditional delivery methods (lecture, laboratory, face-to-face discussion) to include educational options ranging from Web-based course supplements to the complete delivery of courses online. There are endless online choices that instructors may consider in this range, from simply posting a syllabus to creat-

ing Web-based content to enhance classroom instruction to full online delivery. In 1997-98, nearly 44% of all U.S. higher education institutions offered distance-based courses, an increase of one third since 1994-95, with most of the growth being primarily in Internet delivery (National Center for Education Statistics, 2000). The most recent Campus Computing Project (1999) survey identified that 45% of the 530 participating higher education institutions offered at least one full course online.

While the primary focus of Web-based delivery has been in the development of stand-alone Web-based distance education courses, more faculty members are beginning to use the Web to supplement and enhance on-campus instruction (e.g., Goldberg, 1997; Henson, Fridley, Pollock, & Brahler, 2002; Marks, 2002; Masten, Chen, Graulau, Kari, & Lee, 2002;

Mohtar & Engel, 2000; Patterson, 1999; Stith, 2000; Wallace & Weiner, 1998). Data collected by The Campus Computing Project (1999) revealed that 28% of higher education courses have an associated Web page compared to 9% in 1996. The authors have chosen to augment a traditional face-to-face on-campus safety course with an online supplement. This article describes the assessment process used to gauge student perceptions of this new online supplement.

Setting the Stage

The course chosen for the online component was a new junior-level occupational safety course, *Safety in Manufacturing*, required for all industrial technology students at Iowa State University (ISU). This course covers broad topic areas in occupational safety and health from a management or supervisory role in a manufacturing setting. The Web-based supplement, developed using WebCT (see <http://www.webct.com/> for information on WebCT) consisted of outline notes for all course topics, online quizzes, a variety of communication tools, and access to course grades. The course calendar is used to keep students apprised of daily topics, reading assignments, field trips, and due dates for homework and projects. There is a main bulletin board that everyone in the class may access and private bulletin boards that are assigned to each base group to facilitate within-group interaction. WebCT allows students to forward their WebCT e-mail to a different e-mail address should they prefer to receive all of their e-mail at one address. In addition to the communication tools, WebCT was also used to post student grades so that students could access their current grade at any time. This online supplement was initiated the first time this course was offered during the Fall 1999 semester. Freeman and Embleton (2000) provide a more detailed description of the course, the online supplement, and WebCT.

Methods

To gauge the reaction of students to the WebCT supplement for *Safety in Manufacturing*, a student survey instrument was administered. The survey was adapted from work done by the University of Missouri's WebCT Support Team (1999) to meet the authors' needs and address the specific WebCT components implemented. The questionnaire consisted of 13 questions divided into two sections. The first section addressed students'

previous experience with Web-based courses, computer competency, how often and from where they accessed the online supplement, and any problems they encountered. The second section addressed their perceptions of the online supplement. The questionnaire was pilot tested at the end of the Fall 1999 semester with the 34 students enrolled in the course. The questionnaire was distributed with student course evaluations. The completed questionnaires were returned anonymously. The primary purpose of the pilot study was to assess the clarity of the instructions and the usefulness of responses to the questions as written.

Several questions were changed to clarify issues identified during the pilot study. Additional questions were also added to address components of the supplement that were not yet implemented during the first semester (e.g., starting in the second semester, students were required to take an online quiz prior to each class meeting) and to more specifically identify those components of the supplement that the students found useful. In its revised form, the questionnaire consisted of 18 questions and the opportunity to provide additional comments. The questionnaire was administered at the end of each of the following semesters: Spring 2000, Fall 2000, Spring 2001, Fall 2001, Spring 2002, and Fall 2002. Participant responses were anonymous.

Participants completed the questionnaire using pen or pencil. The responses were then archived by coding them into a spreadsheet. Each semester, descriptive statistics of the student perceptions were analyzed as part of the process of preparing the course for the next semester. The data were transferred from the spreadsheet database to a statistical software package for the analysis presented here.

Limitations of This Methodology

As with any self-reported survey, it is typically not possible to verify if the students completed the questionnaire accurately, or honestly. Pilot testing the questionnaire, which indicated that the questions were sufficiently comprehensible to allow the students to answer accurately, reduced some of the potential impact of this limitation. The question of honesty is harder to address. However, the responses were anonymous, had no impact on the students' grades, and were prefaced with a discussion of the need for honest feedback to improve the use of the WebCT supplement for future semesters.

Results

During the six semesters of this study, 210 students completed this course. A total of 178 students completed the questionnaire for an overall response rate of 85%. During these six semesters, the class size ranged from 19 to 47. The response rate ranged from 70.2% to 100%. During the Spring 2000 semester, this class was the first Web-based course experience for over 76% of the respondents. The majority of the students for the next two semesters also had no previous Web-based course experience. Then starting with the Fall 2001 semester, the trend shifted in the other direction, and by the Fall 2002 semester, nearly 92% of the students had previous Web-based course experience. This clear demarcation between the percentage of students who had Web-based course experiences the first three semesters versus the last three semesters provided a natural split that was used in subsequent analyses.

The class met face-to-face twice per week, and in every semester over 90% of the respondents indicated that they accessed the course Web site two or more times per week. The locations from which students accessed WebCT most often were the departmental computer labs and their places of residence. However, the location used most frequently changed from the departmental computer lab (59% in Spring 2000) to the student's house or apartment (69% by Fall 2002). Again, a natural split existed between the first three semesters and the last three semesters. During the first three semesters, over half of the respondents (59%, 59%, and 54%, respectively) used the departmental computer labs as their primary location for accessing WebCT. During the last three semesters, 50% or more of the respondents (55%, 50%, and 69%, respectively) indicated that they most often accessed WebCT from their residence. It should also be noted that significant construction of "Internet ready" student housing was opening up during this time.

When ranking their computing and information technology proficiency on a scale from 1 = *novice* to 5 = *expert*, the industrial technology students responding considered themselves to be competent computer users with 86% giving themselves a rank of 3 or better in Spring 2000 and 100% giving themselves a rank of 3 or better in Fall 2002. As expected, they were able to quickly master the WebCT environment and indicated very few problems interacting with

WebCT. The most common problem during the first three semesters was logging in during the first two weeks of class (24%) and slow response time during the last three semesters (49%).

The WebCT course components considered most useful by the students were the course notes, access to grade information, and the online quizzes. Nearly all (99%) of the students who had previous Web-based course experiences indicated that they preferred this WebCT course to those used in the past. More than 90% of these students indicated that the online notes and quizzes helped them prepare for class. Similarly, 89% indicated that the WebCT component was valuable and improved their learning experience and 92% indicated that they were satisfied with their WebCT experience. The last question on the survey asked if they would prefer a class with a WebCT component to one without such a component, given a choice. Ninety-six percent indicated that they would prefer a class with a WebCT component.

Correlations and Comparisons

The primary purpose of this study was to gauge student perceptions of their experience with the WebCT supplement to *Safety in Manufacturing* to help guide continuing development and use of the online supplement in future semesters. In addition, this study also explored potential differences between student subgroups based on (a) their self-reported computer competency, (b) the components of the supplement they considered useful, and (c) their perceptions of their WebCT experiences. All correlations where a significant ($\alpha = 0.05$) difference between students was found in three or more semesters are presented below. The importance and/or implications of these findings are discussed in the next section.

In all but the first semester, students who indicated that the WebCT component was valuable and improved their learning experience were more likely to consider the WebCT quizzes helpful in preparing for class [the corresponding correlation and p values in parentheses for Fall 2000 through Fall 2002 were .632 (.000), .836 (.000), .525 (.002), .649 (.000), and .406 (.024)] and were more likely to be satisfied with their overall WebCT experience [the corresponding correlation and p values in parentheses for Fall 2000 through Fall 2002 were .561 (.002), .561 (.001), .788 (.000), .818 (.000), and .612

(.000)]. In four semesters, students who ranked their computer competency higher were also less likely to think that they spent too much time learning WebCT [the corresponding correlation and p values in parentheses were Spring 2000, .492 (.045); Fall 2000, .499 (.006); Fall 2001, .377 (.037); and Fall 2002, .461 (.009)]. Students who considered the WebCT course notes helpful in preparing for class were more likely to be satisfied with their overall WebCT experience in four of the six semesters [the corresponding correlation and p values in parentheses were Spring 2000, .553 (.021); Fall 2000, .707 (.000); Spring 2001, .502 (.003); and Spring 2002, .517 (.002)]. During the last four semesters, students who considered the WebCT quizzes helpful in preparing for class were also more likely to agree that access to their grade information prompted them to take action [the corresponding correlation and p values in parentheses were Spring 2001, .349 (.047); Fall 2001, .429 (.018); Spring 2002, .358 (.044); and Fall 2002, .427 (.017)].

In three of the six semesters, students who considered that the WebCT component was valuable and improved their learning experience were also more likely to consider it important to have experience using the latest technology applied to their discipline. During three semesters the students who considered the WebCT notes helpful in preparing for class were more likely to indicate that the notes also facilitated note taking in class. Also during three semesters the students who considered the WebCT notes helpful in preparing for class were more likely to indicate that the WebCT quizzes were helpful in preparing for class. Finally, students who indicated that the quizzes were a useful component of the WebCT course were more likely to indicate that the quizzes helped them prepare for class.

Discussion

Less than 25% of the students enrolled in *Safety in Manufacturing* during the Spring 2000 semester had any previous experience with courses that utilized a Web site. While serious efforts are underway across the country to increase Web-based delivery of educational content, the early focus was on using the Web for complete online delivery—distance education. It was not surprising that relatively few resident students, even in a technology discipline, had been exposed to online components in their courses. Although underutilized at the time,

research was available documenting that students who received a combination of face-to-face instruction with a Web supplement performed better than their counterparts who received only traditional or only Web-based instruction and were much more satisfied with their learning experience (Goldberg, 1997, 2000). This may be particularly true for industrial technology students who are already competent computer users and, as the results confirmed, were able to quickly pick up the intricacies of online delivery even without previous experience. However, WebCT was becoming the standard Web-based instructional platform at ISU and its use across campus was expanding. By Fall 2001 over 60% of the students in *Safety in Manufacturing* had previous experience with a course that utilized a Web site. A year later over 90% of the student respondents had previous Web-based educational experiences. Since they were on-campus students, the majority of these experiences were likely to be Web-based supplements to traditional course delivery methods. It is clear that Web-based components are now common across the campus and in the industrial technology curriculum. It is also noteworthy that as the reliance on Web-based components increased (both through the number of previous courses and the number of access times per week) the students were more likely to utilize access from their residence than from departmental computer labs. However, the fact that more students were accessing their Web-based courses from off campus is likely the reason that more students complained of slow network response time in later semesters.

The three components of the online supplement—course notes, grade information, and quizzes—that were considered the most useful were the components that were used most often. The students did not have a choice in using the online quizzes. They were required to take a preparation quiz prior to each class on the topic to be discussed that day. Each quiz was available for the 48 hours prior to the start of the class covering that topic. The online notes were used by students to help prepare for the quizzes and to facilitate note taking in class. Although it was not encouraged or discouraged in any way, it was observed that by the second week of each semester the majority of the students were printing out the online notes and bringing them to class. These results were corroborated in that

more than 90% of the students agreed that the course notes and quizzes helped them prepare for class. Grades were not posted in hard copy or handed out in class. Instead, updated student grades were posted to WebCT. Since the students were accessing the WebCT component on a routine basis, they developed the habit of checking their grades frequently and letting the instructor know if grades were not accessible within a day of handing in assignments. Information that was accessible to the students included grades for all assignments, current data on overall percentage, class rank, and current letter grade. Having access to current grades at any time also received positive comments in the student course evaluations.

The other three major components of the supplement—bulletin board, calendar, and e-mail—received less enthusiasm. The bulletin board was used to provide general course announcements and provide private feedback to each group concerning group assignments and projects. During the first three semesters, homework assignments were posted to the bulletin board. However, during the last three semesters, the homework assignments were provided in the “Class Resources” section of the WebCT supplement. This seems to have affected the perceived usefulness of the bulletin boards as the ratings dropped more than 10% during the last three semesters. The calendar was probably not deemed as useful as some other components since it duplicated information that was provided in the syllabus; the syllabus was quite detailed and few changes were made to the schedule during the semester. The fact that few of the students considered WebCT e-mail to be useful is explained by the variety of responses to the question on whether they preferred to have the course-related e-mail separate from their personal e-mail. The vast majority of the students already had an e-mail account that they were actively using. The account they used most often was the one they tended to use to communicate with their group members and the instructor. WebCT allows students to forward their WebCT e-mail to a different e-mail address should they prefer to receive all of their e-mail at one address; however, it does not allow other e-mail to be forwarded to WebCT e-mail. Thus, students who wanted only a single e-mail system used one outside WebCT as their primary means of communication with other students and the instructor.

It should be expected that students who believed that the WebCT supplement was valuable and improved their learning were the most satisfied with their overall WebCT experience. If students considered the WebCT quizzes to be useful, it is logical for these same students to use the quizzes to help them prepare for class. If they were using the online notes to prepare for the quizzes, it follows that they would also consider the notes useful in preparing for class. It is therefore not surprising that the students who considered the Web-based supplement to be valuable also considered the quizzes to be helpful in preparing for class. As previously mentioned, the industrial technology students were already competent computer users and were thus able to quickly learn WebCT. It follows that the more competent their computer skills, the less likely they were to perceive learning WebCT as a time burden. What is encouraging is that only two students (of the 173 who responded to that particular question), regardless of previous experience or computer competency, indicated that learning and interacting with the WebCT supplement was a problem. In addition, it seems natural to expect that students who found the online notes useful while preparing for class would use the notes in class to facilitate their own note taking. Since the online notes helped them learn the material, it was expected that those who found the online notes useful would be the most satisfied with their overall WebCT experience. Although students’ response to the online notes is rewarding to the authors, an obvious goal for future semesters is to continue to improve the online notes until all the students find them useful and strongly agree that they help in class preparation.

A positive correlation existed between considering the quizzes to be useful in preparing for class and agreeing that access to grade information prompted them to seek assistance from the instructor or other group members. It may simply be that these students were more proactive in their learning and that the quizzes and seeking assistance from others were both viewed as active measures in learning the material. In addition, a positive correlation existed between regarding the WebCT component as valuable and considering it important to have experience using the latest technology applied to their discipline. This is probably due to the fact that the industrial technology students are competent

computer users and consider Web-based instruction as a “technology” process.

Conclusions and Recommendations

Based on work to date and the results of this study, the following conclusions were drawn:

- Industrial technology students at ISU were already prepared and capable of learning WebCT as a supplement to classroom instruction quickly, regardless of previous experience in using Web-based courses or course components.
- Students appreciated the Web-based supplement to *Safety in Manufacturing* and considered it to be a useful and valuable component to the overall delivery of the course material.
- Students considered the online notes and quizzes particularly helpful to their overall experience in *Safety in Manufacturing*.
- Students considered the access to grade information to be a useful component of the WebCT supplement.
- Students accessed the Web-based material from where they had easy access to the Web—departmental computer labs or personal computers at their place of residence.

The authors believe there are opportunities for faculty members to enhance and improve the educational experience for on-campus students through the use of online course components and encourage all instructors to begin to explore these opportunities. Based on the findings of this project, the following recommendations are suggested for further inquiry:

- Studies need to be conducted to explore the relationships between student perceptions and educational outcomes (e.g., here it was found that students perceived that the online quizzes and notes helped

prepare them for class, but the anonymous nature of the questionnaire did not allow for an exploration of whether the use of these online components resulted in improved class performance).

- Studies need to be conducted to evaluate the use of specific online components (e.g., Why did some students put more value on the online notes? How were they using them? How could they be improved? Were students that valued them using them differently than students who placed lower value on them?).
- Similar studies need to be conducted with other types of courses to determine if student perceptions are consistent across technology curricula. The findings of such studies, if tied to student outcomes, may suggest broad-based curricula reform for on-campus technology courses.

In addition to the recommendations above, industrial technology faculty should also consider whether the lessons learned here and in future studies can be applied to asynchronous delivery of hands-on technology curricula that forms the basis of on-campus technology education.

Readers interested in details of this study in tabular form may contact the authors at sfreeman@iasstate.edu.

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PC-Based Virtual Reality for CAD Model Viewing

Abhishek Seth and Shana S-F Smith

Product design is a critical activity because it has been estimated that 70% to 80% of the cost of product development and manufacture is determined by the decisions made in the initial design stages (Kalpakjian & Schmid, 2001). During the design process, 92% of communications are graphically based (Bertoline, Wiebe, Miller, & Mohler, 1997). Graphics is a visual communication language, which helps designers understand their developing designs and to convey their ideas to others. Thus, efficient graphics communication tools can improve design and decision-making processes.

Most designers currently use traditional CAD tools to help communicate their designs to others. However, CAD tools only allow users to examine 3D models from *outside* flat computer monitors. In other words, the models and the viewers are in different realms. Using traditional CAD tools, the designers cannot view models with natural stereoscopic vision.

Recently, virtual reality (VR), as an emerging visualization technology, has introduced an unprecedented communication method for collaborative design. VR refers to an immersive, interactive, multisensory, viewer-centered, 3D computer-generated environment and the combination of technologies required to build such an environment (Aukstakalnis & Blatner, 1992; Cruz-Neira, 1998). VR technology breaks down barriers between humans and computers by immersing viewers in a computer-generated stereoscopic environment. VR allows users to experience a strong sense of presence in a virtual scene and enhances user interactivity. Using VR technology, depth cues provided by a stereo image help convey spatial relationships in 3D models, which enhances users' understanding of a design. Viewers can perceive distance and spatial relationships between different object components more realistically and accurately than with conventional visualization tools.

Usually, however, implementation of VR technology is not easy. It requires skilled technical people and highly specialized, sometimes costly, equipment. These requirements prevent the widespread use of VR in research and industrial communities (Olson, 2002). However, now,

most PC workstations have stereoscopic graphic display capability built into their graphics card chip sets. PC-based VR techniques, also called low-cost VR, bring VR to a usable level for people with basic technical computer skills and limited resources. Low-cost VR takes advantage of recent advances in low-end graphics systems and other inexpensive VR commodities. Thus, VR solutions are becoming more accessible.

About This Article

This article introduces the current status of VR applications in industry and the technologies involved in the low-cost VR systems. The number of companies producing low-cost VR-related hardware and software is continuously increasing. New hardware and software technical terms are confusing or meaningless to people without any prior background in VR. Thus, choosing the right VR tool for a particular application is challenging for potential users. This article introduces different available stereo image rendering techniques, such as anaglyphic, page flipping, and sync doubling, and major low-cost VR hardware and software tools available for CAD model viewing. The purpose of this article is to help CAD users and product designers have a better understanding about VR technology so that they can develop their own VR systems to increase the efficiency of design communication.

Status in Industry

In industry, VR has proven to be an effective tool for helping workers evaluate product designs (Kelsick, 1998). Using VR enables everyone on a design team to understand designs better, leading to more informed and meaningful communications. Such rapid and less-ambiguous communication greatly enhances the speed and accuracy with which decisions can be made and designs can be completed.

Several major companies have incorporated VR technology into their design or production processes. In 1999, BMW explored the capability of VR for verifying product design (Gomes de Sa & Zachmann, 1999). They concluded that VR has the potential to reduce the number of physical mockups needed, to improve overall product quality, and to obtain quick answers,

in an intuitive way, during the concept phase of a product. In addition, Motorola developed a VR system for training workers to run a pager assembly line (Wittenberg, 1995). They found that VR can be used to successfully train manufacturing personnel and that participants trained in VR environments perform better on the job than those trained for the same time in real environments. In 1998, GE Corporate Research developed two VR software applications, Product Vision and Galileo, which allowed engineers to interactively fly through a virtual jet engine (Abshire & Barron, 1998). They reported that the two applications were used successfully to enhance design communication and to solve maintenance problems early, with minimal cost, delays, and effort. They also reported that using the VR applications helped make maintenance an integral part of their product design process.

Passive and Active Stereo Systems

Because a person's two eyes are some distance apart, upon viewing the same object the right eye sees a slightly different image from the left eye. Therefore, to see a stereo image on a PC screen, one needs to generate different images for the right eye and the left eye, respectively, and arrange the two images such that the right eye sees only the right view and the left eye sees only the left view.

PC-based VR systems typically use one of several types of special viewing glasses to selectively send the right- and the left-eye images to the correct eyes. Depending upon the type of glasses used, stereo systems can be classified into passive or active stereo systems. "Passive" systems use glasses without electronic components; "active" systems use glasses with electronic components.

Passive Stereo Systems

Passive stereo systems are the most common and basic type of stereo systems. They are popular because they are very inexpensive, and cost is often a critical factor in public environments. To the naked eye, passive stereo images appear to overlap and are doubled and blurry. However, when the stereo images are viewed with glasses made from colored or polarized filters, the images become stereoscopic.

Passive anaglyphic systems create a different colored image for the right and left eye. Users then view the colored images using anaglyphic glasses made from colored filters (e.g., blue for the right eye and red for the left eye). Anaglyphic glasses used for passive stereo cost about 80¢ per pair (VRex, <http://www.vrex.com>). However, image quality in passive anaglyphic systems is relatively poor, and colored views are not possible. The lack of colored viewing capability is one of the major drawbacks of anaglyphic passive stereo systems.

Another method for passive stereo viewing is based on the principle of light polarization. With oppositely polarized filters attached to two projectors and matching filters in a pair of glasses, right- and left-eye images can be separated and multiple colors can also be viewed. The theory behind polarized viewing systems is based upon the vibration characteristics of light (Barco, n.d.). Nonpolarized light waves can vibrate in any direction. A light wave vibrating in a single direction is called polarized light. The polarization of a light wave at any given moment is determined by the specific orientation of the wave at that moment. Nonpolarized light can be transformed to polarized light by passing the light wave through a polarizer (see Figure 1). The depth perception required for stereo images can be created by directing

Figure 1. Polarizing light using a polarizing filter.

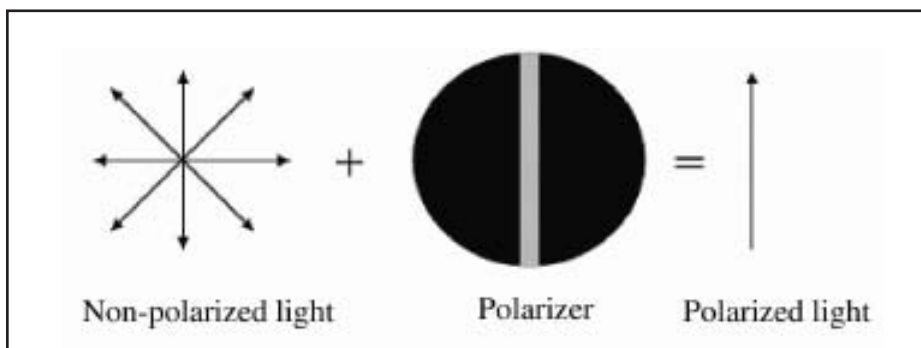


Figure 2. Double projector system with opposite polarizers.



different visual information, using different polarization directions, to the right and left eye. Thus, such a stereo system uses two projectors, as shown in Figure 2. Polarizing light waves does not significantly degrade image quality because human eyes are largely insensitive to polarization. The cost for a polarized projector system is around \$20,000 (VRex, <http://www.vrex.com>; 3-D ImageTeck, <http://www.3dimagetek.com>).

If light is polarized in a single direction (north/south, east/west, or even diagonally), the light is linearly polarized. If a viewer changes the orientation of linearly polarized glasses by tilting his or her head, the resulting polarization orientation of the viewer's glasses will not match that of the polarization filters mounted on the projectors, and there will be a loss of stereo information, as perceived by the viewer (Barco, n.d.). Nevertheless, linear polarization is a cost-effective technology that can produce excellent right-eye and left-eye image separation for stereoscopic applications for which head tilting is limited.

Using circularly, rather than linearly, polarized light is an effective solution to the head-tilting problem. For circularly polarized light, head tilting does not result in a loss of stereo information, since the light is not polarized in a single direction. StereoGraphics Corporation's Monitor ZScreen series provides a stereoscopic panel, which mounts on a regular PC computer monitor, for circularly polarizing right-eye and left-eye images (StereoGraphics Corporation, <http://www.stereographics.com>). The cost of a Monitor ZScreen system is \$2,345. Polarized glasses range in cost from \$3.95 to \$50 per pair (StereoGraphics Corporation, <http://www.stereographics.com>; VRex, <http://www.vrex.com>).

One of the important advantages of polarized stereo viewing systems is that they can be driven by non-stereo-capable hardware. In addition, the polarizing method can provide colored and high-quality stereo images.

Active Stereo Systems

In active stereo systems, the viewing glasses used contain electronic components. Stereo images are presented by rapidly alternating the display of right-eye and left-eye images while alternately masking the right and left eye using synchronous shutter eyewear, such as LCD shutter glasses. Available LCD shutter glasses use various image switching techniques. The following three modes are most popular (Lipton, 1997):

- Interlacing
- Page flipping
- Sync doubling

Interlacing

Interlacing is used in existing television systems, such as NTSC, PAL etc., to transmit and broadcast signals. In interlace mode, a single frame is divided into two fields: the odd scan-line field and the even scan-line field. When the interlace mode is used for stereo imaging, the right-eye image and the left-eye image are divided into odd and even scan-line fields, or vice versa. First the odd scan-lines (1, 3, 5, 7, etc.) are presented, followed by the even scan-lines (2, 4, 6, 8, etc.; see Figure 3). When the right-eye frame is displayed on the screen, the left eye is covered by the glasses, and when the left-eye frame is shown on the screen, the right eye is covered by the shutter glasses.

Figure 3. Interlacing.

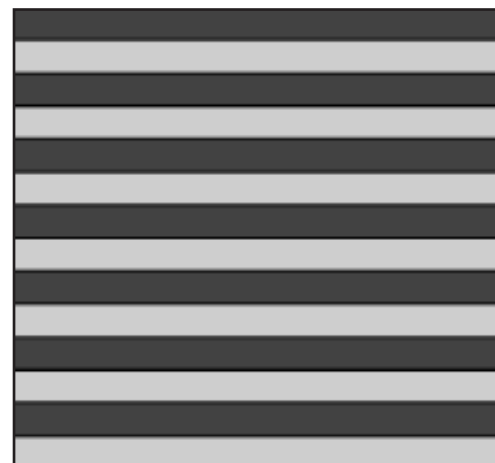
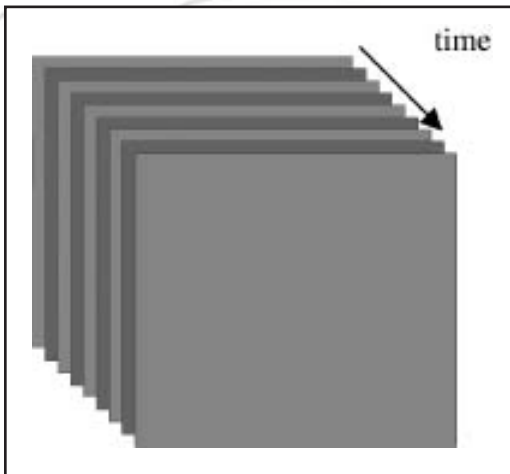


Figure 4. Page-flipping.**Page-Flipping**

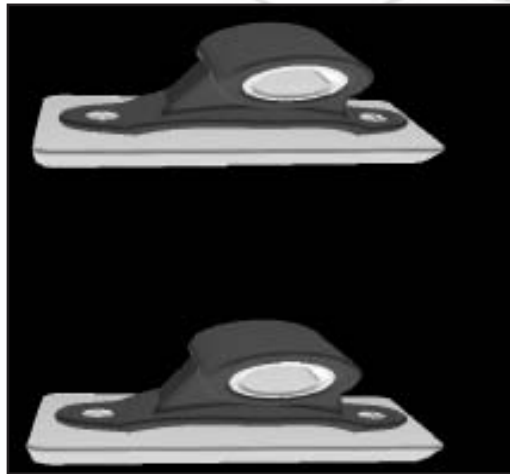
In page-flipping mode, the right- and the left-eye frames are shown alternately on the screen (see Figure 4). When the right-eye frame is shown on the screen, the left eye is covered by the shutter glasses, and when the left-eye frame is shown on the screen, the right eye is covered by the shutter glasses. In this mode, both the horizontal and vertical resolutions are kept the same, since the frames are displayed one by one on the entire screen.

For page-flipping, high-end PC hardware is typically required. A monitor that supports a 120 Hz or higher vertical scan frequency and specially designed hardware are often required. As mentioned earlier, page-flipping provides full resolution picture quality and, thus, provides the best visual effect among the display modes for shutter glasses. However, software and hardware dependence is a major drawback.

Sync-Doubling

With sync-doubling, the right-eye and left-eye frames of the image are scaled down in the vertical direction and arranged on the upper and lower half of the screen (see Figure 5). Sync-doubling differs from interlacing and page-flipping modes in that no specialized computer peripherals are required.

To create a stereo view, software designers only need to arrange the right- and left-eye images properly on the screen, as shown in Figure 5. An external circuit (called a sync doubler) is then used, which allows the right- and left-eye images to stretch to normal size and appear in an interlaced pattern on screen. The image quality is not as good as page flip-

Figure 5. Sync-doubling.

ping because the monitor's vertical frequency needs to be doubled to stretch the frames to full screen. Overall image resolution is therefore reduced by one half. However, the advantage of sync-doubling is that it is not limited by computer hardware capabilities.

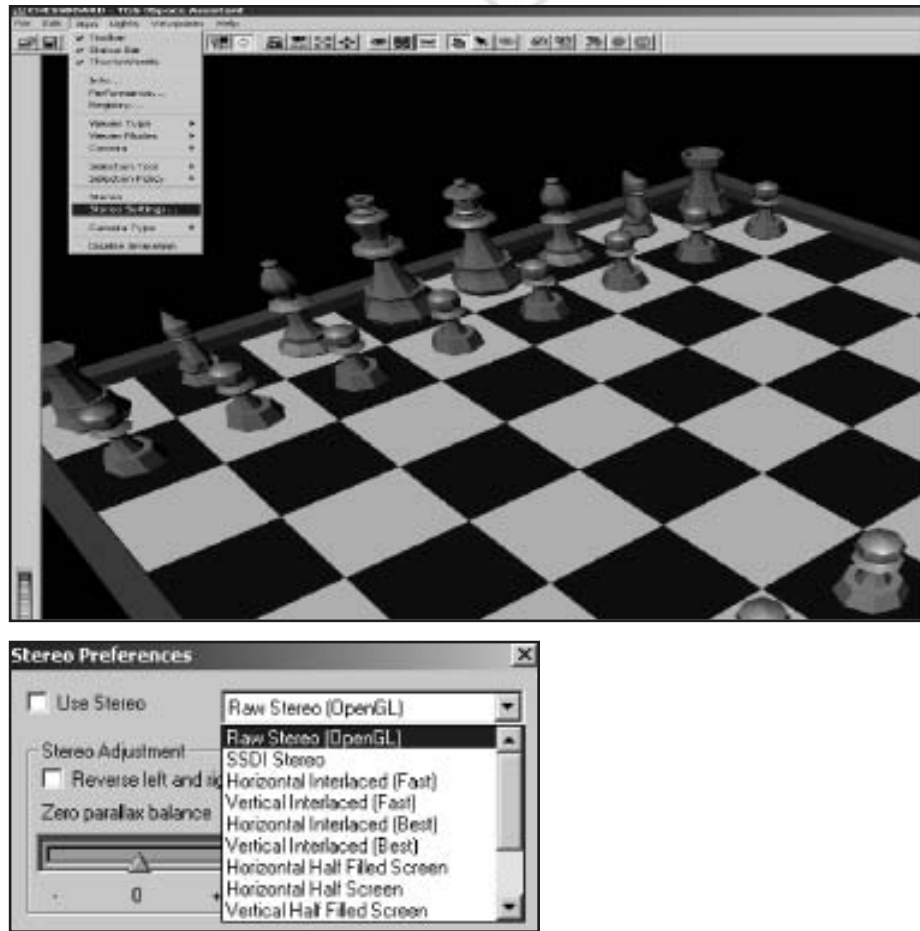
Available Software

Presently, there are a number of VR software tools available for stereoscopically viewing CAD models. For example, 3Space Assistant by Template Graphics Software (<http://www.tgs.com>) and Quadro View by Nvidia Corporation (<http://www.nvidia.com>) are well developed and very user-friendly.

For the available software tools, the computer system must have an OpenGL driver installed to activate stereo modes. OpenGL is a cross-platform, high-performance standard library for 3D graphics applications. If an OpenGL driver for the graphics card being used is unavailable or if the driver is not installed when the active stereo mode is used, the computer will display the message "No OpenGL driver installed on the computer," and the stereo image will not be shown on the screen. GL Direct, by SciTech Software Inc. (www.scitechsoft.com), provides a solution to the above problem. After the software is installed, whenever any stereo application (e.g., TGS 3Space Assistant or Quadro View) starts, SciTech GL Direct will automatically start.

TGS 3Space Assistant

3Space Assistant from Template Graphics Software, Inc., is a stand-alone CAD model viewer. The advantage of 3Space Assistant is that it allows stereo viewing in a number of

Figure 6. Stereo settings in the view menu of 3Space Assistant.

stereo modes such as Raw OpenGL, Horizontal Interlaced, Vertical Interlaced, Red-Cyan Anaglyphic, and Blue-Yellow Anaglyphic (see Figure 6). If the active stereo mode is used, LCD shutter glasses are required. If the anaglyphic stereo mode is enabled, passive colored filter glasses (red/cyan, blue/yellow, or green/magenta) are required.

Nvidia Quadro View

To use Nvidia's Quadro View, users need to purchase a quad-buffered graphics card or a computer system that already has a quad-buffered graphics card installed (Nvidia Corporation, <http://www.nvidia.com>; Redmond, n.d.). The stereo quality provided by Quadro View is very good, but the part handling features are not very user-friendly. Using Quadro View, 3D CAD models can be viewed using passive as well as active stereo modes. One of the unique features in Quadro View is its compatibility with other CAD design packages (e.g., AutoCAD, AutoCAD Architectural Desktop, and Mechanical Desktop), which makes it different from all other stereo viewers.

Future Directions

PC-based VR, in the future, will incorporate haptic and audio devices to give a better sense of immersion in the computer-generated environment and to provide a more intuitive interaction with design models. Haptic devices could provide realistic force feedback so users could feel objects that they touch or move. Audio devices could provide realistic sound effects for collisions between objects. In addition, because of the restrictions associated with manipulating 3D virtual objects with a keyboard and mouse, data gloves will be used to increase manipulation efficiency in low-cost VR systems. Handling computational workloads while providing real-time response is also a critical issue for realizing future low-cost VR systems.

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Technology Profile: An Assessment Strategy for Technological Literacy

Charles W. Gagel

Given the scope of technology and the inherent difficulties of measuring such broad phenomena, this article explores two strategies for assessing technological literacy. One approach is drawn from a multiple measurement strategy often used to assess achievement, the test battery approach; the other is based on well-known interest inventories and personality type indicators, the typology approach. Shared between these approaches is the notion of a profile. One's performance or rating could be reported through a profile, that is, "a formal summary or analysis of data, often in the form of a graph or table, representing distinctive features or characteristics" (The American Heritage Electronic Dictionary, 1992).

While it is undeniable that the creation of such measures would be demanding given the conceptual scope of the undertaking, such efforts are called for in a report by the Committee on Technological Literacy—a joint committee of the National Academy of Engineering and the National Research Council, Center for Education (Pearson & Young, 2002). Specific recommendations were made for "the development of one or more assessment tools for monitoring the state of technological literacy among students and the public in the United States" (p. 12).

In principle, a technology profile could provide a means by which one's technological prowess or disposition could be indexed or classified according to a determined scale or system. Such a profile could aid in (a) the identification of potential students for a given program, (b) the comparison of one's capabilities to a known group, (c) the determination of one's technological knowledge and skill in a particular area of technology, or (d) the classification of one's disposition toward technology.

The Test Battery Approach

The battery approach for a technology profile is based on a common method used by many measurement instruments when several

dimensions of a phenomenon are to be measured. A single instrument approach is usually avoided because to accommodate the breadth of the phenomenon the test instrument would need to be very large, and thus too time consuming and laborious to administer or complete. In these situations, a battery of tests are employed with each test measuring a specific area of the phenomenon.

The well-known General Aptitude Test Battery and Differential Aptitude Tests are two examples of such multiple test strategies. A more recent and related example can be found in the Technology and Internet Assessment (Ealy, 1999). This assessment battery is designed to determine one's strengths and weaknesses in eight areas related to computer, Internet, and information skills. The eight areas are titled (a) Use of Technology, (b) Specific Computer Skills, (c) Acquisition of Technology Knowledge, (d) Basic Internet Knowledge, (e) Internet Information Skills, (f) Adapting to Technological Change, (g) Impact of Technology, and (h) Ethics of Technology. Such a model could be adapted for measuring the broad spectrum of technological knowledge, skills, and disposition.

Given the array of content now being promoted for the technology education curriculum through the Standards for Technological Literacy document (International Technology Education Association [ITEA], 2000), it is difficult to imagine that a single test approach would adequately measure the intended literacy. In combination with the assessment standards set forth in the recent Advancing Excellence in Technological Literacy document (ITEA, 2003), a single test approach does not seem reasonable. It would seem that the development of a battery of tests would serve both the content and assessment standards better. Just how such a test battery might unfold is unknown; however, certain reports are conceptualized below to help guide an overall development process.

Figure 1. Conceptual representation of a Technology Profile.

Name: _____ Test Form: _____

TECHNOLOGY PROFILE

Individual Profile Chart & Cumulative Record

Record of Testing:

Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____

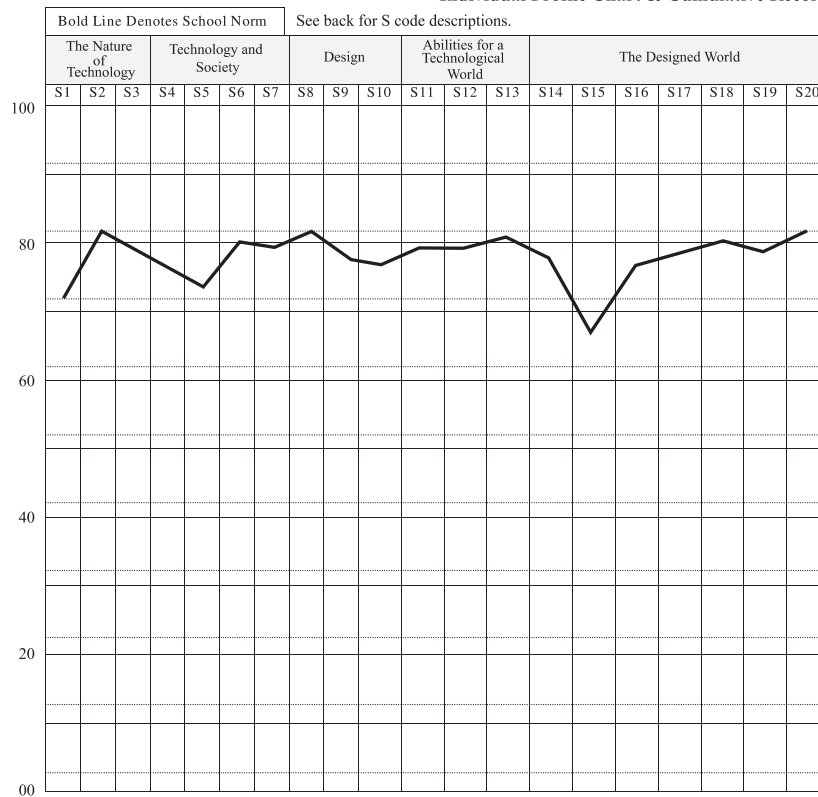
Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____

Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____

Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____

Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____

Date: _____ Date: _____
Standard: _____ Standard: _____
Score: _____ Score: _____



S Code Descriptions

The Nature of Technology <i>Students will develop an understanding of . . .</i>
S1: the characteristics and scope of technology.
S2: the core concepts of technology.
S3: the relationships among technologies and the connections between technology and other fields of study.
Technology and Society <i>Students will develop an understanding of . . .</i>
S4: the cultural, social, economic, and political effects of technology.
S5: the effects of technology on the environment.
S6: the role of society in the development and use of technology.
S7: the influence of technology on history.
Design <i>Students will develop an understanding of . . .</i>
S8: the attributes of design.
S9: engineering design.
S10: the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Abilities for a Technological World <i>Students will develop the abilities to . . .</i>
S11: apply the design process.
S12: use and maintain technological products and systems
S13: assess the impact of products and systems.
The Designed World <i>Students will develop an understanding of and be able to select and use . . .</i>
S14: medical technologies.
S15: agricultural and related biotechnologies.
S16: energy and power technologies.
S17: information and communication technologies.
S18: transportation technologies.
S19: manufacturing technologies.
S20: construction technologies.

Note: This page is the back of the Technology Profile.

Figure 2. Conceptual representation of a Technology Profile and Summary Report.

For: John J. Jones
3546 Clearwater Creek Road
Somewhere, USA 01010-3546

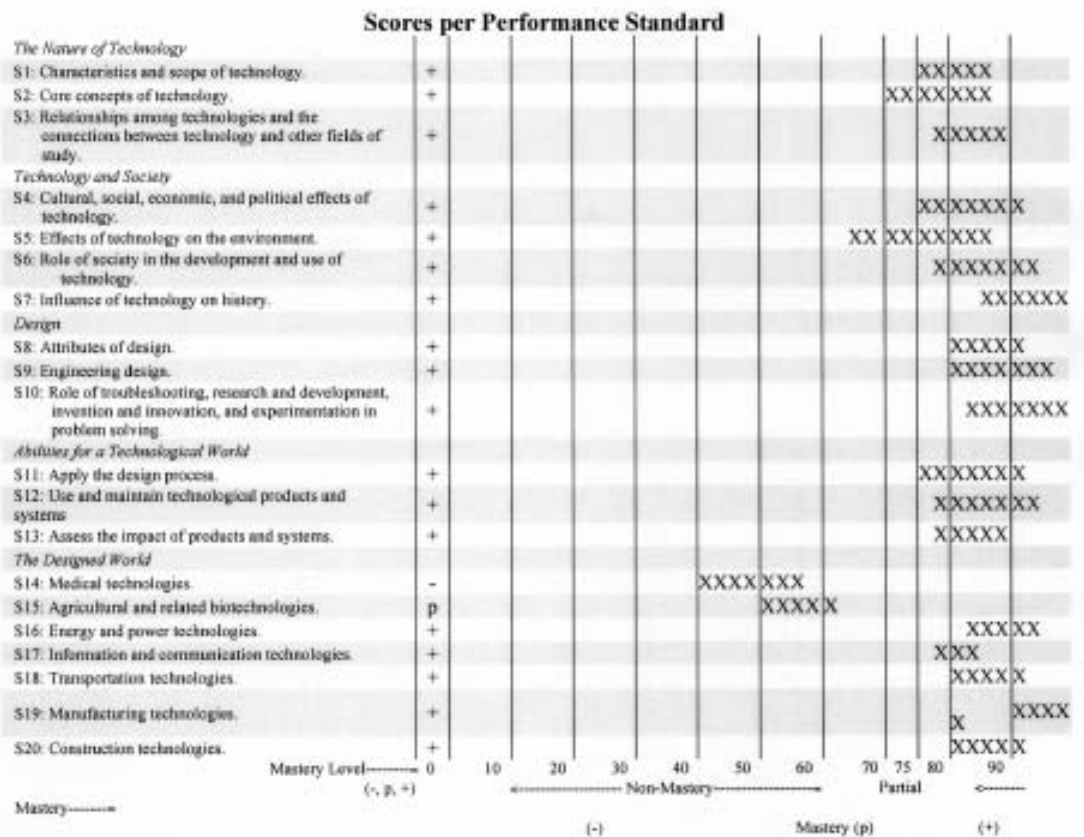
Date: November 14, 2004

Test Form: A Level: 10

Test Cluster	Score	Comparison Norms		
		School	Regional	National
The Nature of Technology	81	80.6	78.2	82.5
Technology and Society	84	81.0	80.0	80.9
Design	87	82.0	83.9	86.0
Abilities for a Technological World	85	83.3	79.4	80.0
The Designed World	80	80.8	78.4	78.3
Combined Score	417	407.7	399.9	407.7

School: Mountain Crest High School
7834 Mountain Crest Road
Somewhere, USA 01011-7834

Class: TE 310/Wilson
Room: 127



Note: On your profile, a bar of X's has been printed in the row for each performance standard. Your score is at the center of the bar. The reason for the bar instead of a single X is that a test is not a perfect measure of your knowledge, skills, or ability. You can be reasonably sure that you stand somewhere within the area covered by the bar.

Technology Achievement Profile

In addition to the test battery design, the notion of a technology profile draws on certain data representation associated with various survey and inventory instruments. This aspect of the profile could serve to compare one's scores on the overall battery of tests with the characteristic scores of others. Scores on the individual tests of the battery (i.e., subtests) could be reported in such a way as to provide an overall portrait of one's performance or rating. Such reporting is often done in the form of charts or derived scores. Two possible models are described below. It should be noted that Figures 1 and 2 are conceptual representations only; the test to generate these reports has not been created or administered. All the data displayed in the profiles, therefore, are fictitious.

The first model, the *Technology Profile* (Figure 1), provides a graphic display of one's performance on 20 different subtests. For our purposes here, the subtests are based on the 20 content standards set forth in the Standards for Technological Literacy (ITEA, 2000). This model promotes the idea of an individual profile chart and cumulative record. The graphical depiction also provides a means for comparing one's scores to other established scores, for example, a cumulative overall school or school district's performance.

The second model, the *Technology Profile and Summary Report* (Figure 2), provides scoring bands for the 20 content standards in addition to grouped scores for the five divisions of the content standards: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World. The scoring bands (bars of Xs) represent the confidence range for the given test score. Comparison norms for the individual school, region, and nation are also included. One's achieved level of mastery is incorporated into the report as well.

Given these two forms of reporting, one could compare an individual's score to those of his or her classmates or to much broader groups. It would allow for comparisons between the many subcategories of technology. Such an approach could provide a multidimensional portrait of technological literacy.

The Typology Approach

A truly unique approach for a technology profile could come in the form of a typology indicator, that is, a depiction of one's attitudes toward technology. From a general education perspective, given the ephemeral nature of technological knowledge and skills, this approach could prove more meaningful over time. Such an instrument would have greater longevity (i.e., shelf life) and could provide information that a competency scale would normally overlook. The profile could be based on survey and inventory type instruments, for instance, the personality scales of the Myers-Briggs Type Indicator (MBTI) and the Keirsey Temperament Sorter (KTS). Here, one's knowledge, skills, and attitudes regarding technology could be used to sort and categorize individuals according to some scale of technological capacity, interest, or disposition.

The MBTI uses four dichotomy scales to produce 16 different personality types. Two of the four scales deal with mental functions (i.e., thinking/feeling and sensing/intuition) and two deal with attitudes (i.e., extraversion/introversion and perceiving/judging). The KTS divides these 16 types of the MBTI into four major categories (i.e., artisans, guardians, idealists, and rationals). Each of the four categories is then divided into four subcategories, each with its own descriptor (see Table 1). Using the MBTI and KTS as models, a technology disposition profile is discussed in the next section.

Technology Disposition Profile

Developing a technology disposition profile would require the creation of dichotomous scales for a variety of attitudes and sentiments toward technology. In keeping with the MBTI (where the scales follow along mental and attitudinal lines), the scales for a technology disposition profile would follow the same logic, that is, mental and attitudinal. Mental functions could be viewed as the mental dispositions (i.e., habits of mind) of certain creators and users of technology; attitudes could be cast along the lines of application and consequences (e.g., Engineer : Utility :: Artist : Aesthetics or Environmentalist : Conservation :: Producer : Consumption). Such scales might resemble those shown in Table 2.

Table 1. Types and Temperaments According to the Myers-Briggs Type Indicator and Keirsey Temperament Sorter

Artisans	Guardians	Idealists	Rationals
Promoter (ESTP)	Supervisor (ESTJ)	Teacher (ENFJ)	Fieldmarshal (ENTJ)
Crafter (ISTP)	Inspector (ISTJ)	Counselor (INFJ)	Mastermind (INTJ)
Performer (ESFP)	Provider (ESFJ)	Champion (ENFP)	Inventor (ENTP)
Composer (ISFP)	Protector (ISFJ)	Healer (INFP)	Architect (INTP)

Note: E = extraversion, I = intuition, F = feeling, J = judging, N = introversion, P = perceiving, S = sensing, T = thinking.

Table 2. Potential Dichotomy Scales for Attitudes Towards Technology

Creators / Users	Applications / Consequences
Designers / Producers	Products / Costs
Producers / Consumers	Services / Benefits
Management / Labor	Resources / Environment
Government / Citizenry	Political / Economic

Discussion

The notion of a technology profile, as just described, raises a number of questions. For instance, given the 20 content standards developed by the ITEA, is it conceivable that they could serve as the constructs for test development? If each standard was used for a separate instrument, 20 individual tests would likely be viewed as too cumbersome to develop and administer. Would it be more manageable then to use ITEA's five major divisions of the content standards to guide test development? Would five tests be adequate? Given the breadth of technology, five tests would seem limiting especially if one's everyday lived encounters with technology were to be included. Everyday lived encounters go beyond what can be expected from the typical classroom education. There are issues of learned versus acquired literacy here (Gee, 1989).

A possible compromise might draw on both the standards and their divisions. A combination approach may be comprised of 10 separate instruments; for example, the test titles

may be as follows: The Nature of Technology, Technology and Society, Design in Technology, Medical Technologies, Agricultural and Related Biotechnologies, Energy and Power Technologies, Information and Communication Technologies, Transportation Technologies, Manufacturing Technologies, and Construction Technologies.

The above discussion has addressed a few of the issues surrounding the more traditional test battery approach; the typology approach would have similar concerns regarding scope and size. Given the number of occupational interest inventories and scales that are available today, would developing a type sorting scale for technological dispositions add a meaningful dimension to our measurement of technological literacy? What might such a measure of beliefs and attitudes add to our understanding of technological literacy?

The typology scale, as conceptualized here, goes beyond occupational interest and fit. It seeks to investigate further than one's conscious

knowledge, skills, and motivation. The objective is to gain an understanding of one's dispositions toward technology—those beliefs and attitudes that have both conscious and unconscious origins. It can be argued that one of technology's most serious liabilities as a legitimate domain of knowledge is its growing invisibility. There are two dimensions to this invisibility. First, there is one's familiarity with technology; that is, as one interacts with technology on a daily basis, one's awareness of that interaction is dimmed. This is often explained as a level of *automaticity*, a state in which one acts without attending much conscious effort. In this dimension, the more one interacts with and is dependent upon technology, the less one realizes and appreciates the interaction.

The second dimension of technology's invisibility is based on technology's own evolution. As technology advances, it becomes more invisible. In today's computerized world, we talk about a seamless interface. Essentially, this means an invisible blending of multiple components. This invisibility masks the real complexity of what is transpiring; it simplifies the technology for the human user. This phenomenon of simplification often results in a lack of awareness and appreciation of the technology. The simplification masks many of the implications or impacts of technology on the individual, the society, and the environment.

Closing Thoughts

There remain numerous questions regarding the viability of a profile approach for technological literacy. The test taker's own mental endurance (potential boredom, for instance) must be considered when determining the size and number of tests in a battery. Like many other test batteries, the individual tests can be spread over a period of days, weeks, or perhaps months. Since each test would address a specific area of content, boredom and a sense of repetition could be minimized.

Another consideration must be one of *perception*. How will these tests be viewed by teachers, administrators, parents, or the general public? In our era of high-stakes testing, adding another layer of testing would likely be met with resistance. Consequently, as mentioned earlier,

technology's misunderstood nature is one of the greatest challenges when it comes to perception. At the school level, devoting time out of the school day to measure technological literacy will ultimately be gauged against its perceived value with mathematics, language arts, science, and other school subjects. Hence, it must be acknowledged that technology still struggles for a place in the greater sociology of knowledge.

The notion of a technology profile has other entanglements with perception as well, for instance, the negative image of *profiling*. Could one's technology profile be used in a negative way? Could it be used to unfairly stereotype individuals? While one must admit that such an outcome is possible, it is certainly not the intent.

Whether a test is required or elective holds still other perceptual concerns. The technology profile is not envisioned as a mandatory test unless, perhaps, the study of technology achieves a required status in the total school curriculum. It should be further understood that a technology profile may not necessarily be part of the K–12 schooling experience at all. A profile could have value in both school and non-school settings, as with many other tests related to technical or workforce matters.

Perhaps the most difficult challenge for developing a technology profile, whether for the test battery approach or the typology approach, would be the creation of the test items or statements. Validity, and perhaps reliability, will indeed be a challenge. Even though every human being encounters technology everyday, it is the diversity, combined with a certain level of competency, that is problematic. Here, we can take a lesson from the field of artificial intelligence (AI).

At one time, AI held much promise for aiding complex decision making. It was believed that if we could create a large enough database and access it with an appropriate algorithm that AI would be able to answer almost any complex question. In reality, the diversity of the human knowledge base and the complexity of human situations have proven much more difficult than originally recognized. AI has given us many very useful problem-solving tools but mostly in

very restricted environments (e.g., selected medical and engineering applications).

The AI lesson for measuring technological literacy is twofold: (a) context must be limited and (b) multiple, more narrowly defined tests produce better results. Validity hinges primarily on the first point; namely, validity must consider the background and/or setting of the one being tested. Thus, it could be argued that with technology's diversity across human culture, it would not seem unreasonable to design a given test for a particular region of a country or, perhaps, even for urban versus rural encounters with technology. While this may seem to further complicate the issue, its intent is to draw attention to the matter of application. Technology is fundamentally an applied subject by nature. Test items and statements will be valid to the extent that they measure what one *knows about* technology and what one is *able to do* with technology within a given context. To not include these

aspects of technology will yield an incomplete measure of technological literacy and thus limit the validity of the overall test.

Finally, the technology profiles conceptualized in this article are intended to promote our thinking about the assessment of technological literacy. With the growing emphasis on standards and their assessment, the technology profile may provide an alternate means for documenting one's achievements and dispositions toward technology. While such an approach would surely require an extensive development effort, it would seem that the complexity and scope of technological literacy warrants such an approach.

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Author Note

Figures 1 and 2 in this article are based on the reports used by the Iowa Tests of Basic Skills and the Comprehensive Tests of Basic Skills.



A Comparison of Industrial and Academic Perceptions of Quality Control Education

R. Neal Callahan and Shawn D. Strong

Effective quality control is easily recognized as a key component in successful manufacturing operations. Companies place a high priority on establishing a strong quality management team and sound quality procedures, yet many employers find newly hired technical graduates unprepared to apply quality control concepts learned in the classroom. Companies realize that the success of their quality program has a substantial influence on their bottom line. Quality program effectiveness is directly related to profitability through its impact on productivity, product cost, customer satisfaction, product image, and, ultimately, attainable product price. Considerable resources are spent on either training existing employees or hiring additional ones who are well versed in quality control principles.

Educators in technical programs share in this concern for developing well-trained graduates who are competent in a variety of quality related topics. Technology-based programs typically include one or two courses focused on quality topics. As in industry, educators spend a great deal of resources and effort developing appropriate quality related courses, faculty, and facilities.

The purpose of this study was to investigate the perceptions of both industry professionals and faculty members of technology-based programs concerning the preparedness of recent graduates as they began a quality related position. To gain this information, surveys were administered among managers and technical leaders in industry and compared with surveys of faculty members from four-year industrial technology and engineering technology programs. Recent graduates were evaluated with regard to both theoretical knowledge and applied skills. By analyzing survey results, recent literature, and in-depth conversations with industry professionals, recommendations are made for improving quality control curricula and better serving industry needs.

Background

Quality control on the plant floor is practiced much differently than it is presented in the

classroom, with numerous opportunities for inaccurate data collection and unclear conclusions (Schenck, 1993). Experienced quality professionals often find that newly hired graduates have difficulty with issues such as gaging, data interpretation, and conforming to a production and cost-oriented environment. While many of these issues are a matter of experience, both industry professionals and the related literature indicated that applied quality concepts should be added to basic quality control curricula at the college level. Every effort should be made to strengthen students' skills by combining theoretical knowledge with practical situations (Kemenade & Garre, 2000).

Successfully applying quality control concepts on the shop floor requires the ability to overcome common problems such as incomplete data, inaccurate measurements, and non-normal distributions. Dealing with these types of problems can be challenging for those who have been exposed to rigid statistical standards for quality analysis in the classroom. Wheeler and Chambers (1992) indicated that many techniques can be used even when less than perfect conditions such as non-normal distributions and unstable processes exist. In addition, an understanding of the ways in which the process and product impact the analysis of quality data is critical in making correct judgments (T. Dorsey, personal communication, June 6, 2003). Familiarity with basic data collection procedures and protocols, along with an understanding of quality standards and reference material, is also expected. These requirements may seem overwhelming for those in entry-level positions, but exposure to a few key concepts before graduation can make the transition much easier. Demanding production schedules and cost constraints can be additional complications for the quality professional to overcome. The key to success is an ability to understand and address these problems without abandoning basic quality theory and standards.

Previous Work

Previous studies have investigated methods for improving quality control skills of employees. Rungtusanatham (2001) surveyed

production personnel to assess the impact of quality control training. His findings indicated an improvement in motivation and job performance as quality control skills increased. Improved quality control practices by employees also have an impact on customer satisfaction according to Nilsson, Johnson, and Gustafsson (2001). Suleiman and Yourstone (1998) investigated the effects of training, performance evaluation, and rewards on the successful implementation of a quality management program. Developing a sense of value for quality among workers is of particular importance. Deming (1994) concluded that external monitoring or bonuses are not the basis for an effective quality system. Instilling a value of quality for its own sake based on the pride and self-esteem of the workers results in long-term success. A survey conducted by Rao, Raghunathan, and Solis (1997) indicated that quality assurance performance was affected by length of quality experience in organizations.

Folkestad, Senior, and DeMiranda (2002) explored service learning as a method for developing students' social attitude toward work along with strengthening technical literacy. This method does hold some promise for strengthening practical skills by increasing exposure to real projects with real problems. However, caution should be exercised to assure that the technical content of the project is demanding enough for the particular course of which it is a part. Focusing on social development in a technical course could reduce exposure to and comprehension of specific skills that will be needed later. Plaza (2004) proposed an integrative approach to technology education in which core courses are developed around a topic involving many disciplines and many instructors. This approach could be successful at the introductory or capstone levels, but could also trend toward an excessive number of survey courses that would reduce the focus and depth of the program.

Bhote (1991) concluded that 90% of U.S. industry is not successful in solving chronic quality problems. He promoted the teaching of very powerful, but simple, statistical tools for dealing with persistent problems.

The previous studies have indicated that quality control training can have a positive impact on employee performance. With a grounding in these findings, this study sought to

determine specific quality skills employers expect in entry-level professionals. A comparison of what is expected by employers versus what is emphasized by academia was then investigated.

Survey Methodology

Both industry professionals and college faculty members were surveyed to gauge and compare expectations concerning quality control education. A questionnaire survey instrument was developed and a pilot test was conducted with colleagues and industry professionals who had significant roles in quality control. The pilot test was conducted to check the validity of the questionnaire, identify and eliminate any ambiguity, and make appropriate changes identified by respondents' suggestions. Recommendations from the pilot test were incorporated into the final version of the survey and included issues concerning specific topics covered, wording of certain questions, and the form of the survey itself (see Figure 1 for the final version of the survey questionnaire).

Two populations were targeted for the survey. One population consisted of a database of industry professionals maintained by the college department conducting the survey. This database was made up of production and quality assurance professionals who maintained contact with the department and had involvement in applying quality control concepts in the national or international manufacturing environment. A second population consisted of college faculty who were members of the engineering technology listserv, which included technology-based faculty across the United States. A qualifying statement with the survey narrowed this population to faculty of four-year industrial technology or engineering technology degree-granting institutions who were involved in teaching quality control. All surveys were sent via e-mail.

The survey employed twelve 5-point Likert scale questions and one rank order type question. The 5-point Likert scale design consisted of: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, and (5) strongly agree. The achievement of new technology graduates was evaluated with respect to six knowledge areas in quality control: basic statistics, statistical process control, measuring equipment, non-normal distributions, gage control, and documentation standards. Each knowledge area was evaluated using a paired format consisting of a

Figure 1. Survey questionnaire.

The following survey questions relate to recent college graduates from four-year Industrial Technology or Engineering Technology programs entering the industrial workforce. Assume that the graduates will be significantly involved with the quality control function in their first assignment.

Do recent graduates from technology based programs possess the following knowledge and skills?

Check one of the five boxes for each knowledge or skill listed.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Graduates have adequate knowledge of basic statistical theory					
Graduates have adequate skills in applying basic statistical concepts					
Graduates have adequate knowledge of statistical process control theory					
Graduates have adequate skills in applying statistical process control concepts					
Graduates have adequate knowledge of basic measuring equipment					
Graduates have adequate skills in using basic measuring equipment					
Graduates have adequate knowledge of non-normal distributions					
Graduates have adequate skills in applying non-normal distributions to analyze data					
Graduates have adequate knowledge of gage control concepts					
Graduates have adequate skills in applying gage control concepts					
Graduates have adequate knowledge of data collection and documentation standards					
Graduates have adequate skills in applying data collection and documentation standards					

Of the following quality related areas, rank the top three items (1, 2, 3; 1 = highest priority) that you feel most need **additional** attention in technology based programs. If an item is not listed please write it in the space provided. **Only select the top three items – leave all others blank.**

- | | | |
|--|---------------------------------|---------------------------|
| ___ Statistical Process Control | ___ Gage Control | ___ Design of Experiments |
| ___ Basic Statistics | ___ Capability Studies | ___ Measuring Equipment |
| ___ Data Collection Standards | ___ Economic Aspects of Quality | ___ Hypothesis Testing |
| ___ Non-Normal Distributions | ___ Rational Subgrouping | ___ Sampling |
| ___ _____ (list an additional item if not given) | | |

statement relating to theory and a second statement relating to applied skill.

The rank-order portion of the survey listed 12 items for the participants to consider. A blank was provided that allowed an additional item to be added if it was not already listed. Participants were asked to rank the top three quality control items (1, 2, 3; 1 = highest priority) that they felt most needed additional attention in technology-based programs. This portion of the survey was evaluated by applying a number score to the ranked responses. For clarity this priority scale was then inverted. Quality control items rated with the highest priority were assigned a score of 3 followed by 2 and 1 for lower priority rankings. In this way graphical priority ratings may be more easily interpreted.

A total of 28 useable questionnaires out of 64 were returned by industry professionals for a response rate of 44%. Three industry questionnaires were discarded due to incomplete responses. A total of 32 faculty members returned surveys from an original population of approximately 175 for a response rate of 18%. One faculty questionnaire was discarded due to improper ranking of items in the rank order portion. The faculty response rate was approximated based on the engineering technology listserv membership of 1,396 for four-year colleges. A spot check of five institutions revealed that about 1 out of 8 faculty members from technol-

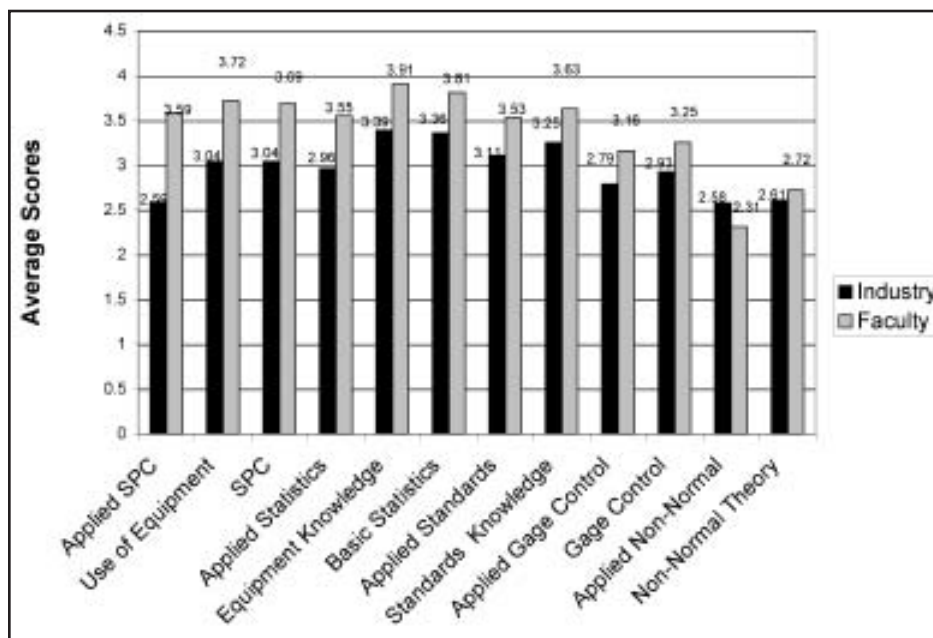
ogy-based programs were involved in teaching quality control courses. This reduced the target population to approximately 175.

The Likert portion of the survey strongly indicated the rejection of the null hypothesis associated with the means test indicating the sample sizes were sufficient to identify differences between the two groups (see survey results). The rank order portion of the survey revealed that approximately half of the respondents chose the top three ranked items. According to Cochran (1977), a minimum sample size of about 30 is needed to ensure validity if the population proportion is approximately 0.50. Based on the above guidelines, we would classify any conclusions drawn from the study to be cautiously valid.

Survey Results

The survey was intended to evaluate the abilities of recent graduates from two different perspectives: industry and academia. The first part of the survey consisted of 12 statements that were rated according to the Likert scale previously described. In comparing the two survey groups, we examined which knowledge areas exhibited significantly different responses between industry professionals and college faculty. To illustrate this comparison, data from both groups were summarized in a single bar graph and listed in descending order of differential magnitude (see Figure 2).

Figure 2. Combined bar chart for knowledge area ratings.



The greatest difference between ratings scores occurred in the applying SPC category. A large difference in ratings also occurred in evaluating knowledge of SPC. This is surprising considering the attention and effort expended on this topic by both industry and academia. Other areas that showed a large difference between the two evaluation groups include knowledge and use of equipment, statistical theory, and applying basic statistics. The overall evaluation of recent graduates' knowledge and abilities is noticeably lower from the industry professionals averaging 2.97 compared to the college faculty group which assigned an average score of 3.41. In order to determine whether the differences in

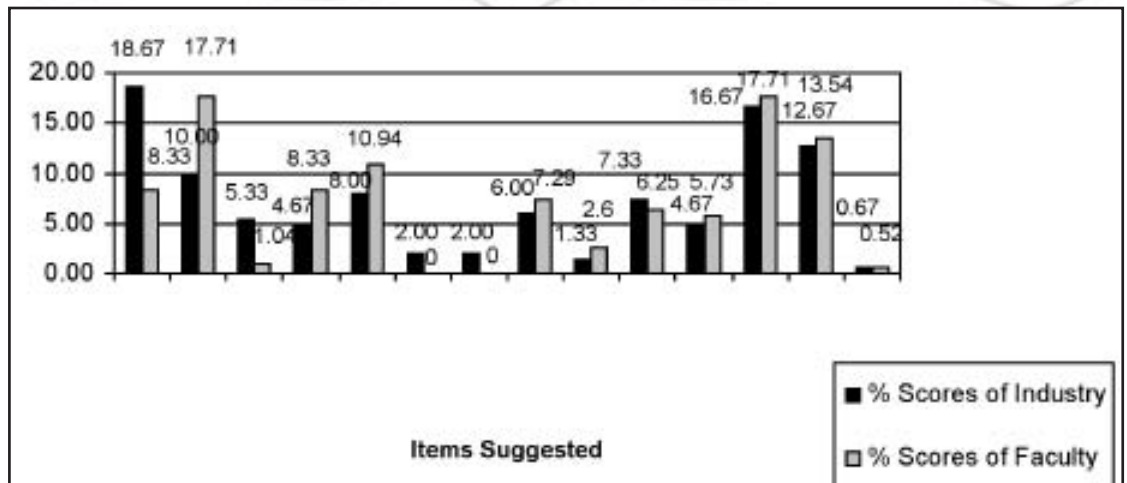
ratings between industry and academia were statistically significant, a means test (t test) was performed for each knowledge area. The results of these tests are shown in Table 1.

Table 1 indicates a statistically significant difference between industry and academic ratings for SPC theory and application, equipment knowledge and use, and applying basic statistics. In all of these categories the faculty ratings were significantly higher than the industry ratings.

The rank order portion of the survey was designed to identify the most crucial topics that

Table 1. Means Tests for Theory Versus Academic Ratings

Knowledge Area	Means		t Value	p Value
	Industry	Faculty		
Applying SPC	2.59	3.59	-4.16	.000*
Use of equipment	3.04	3.72	-2.88	.006*
SPC theory	3.04	3.69	-2.51	.015*
Applying basic statistics	2.96	3.55	-2.13	.037*
Equipment knowledge	3.39	3.91	-2.32	.024*
Basic statistical theory	3.36	3.81	-1.82	.074
Applying standards—data collection and documentation	3.11	3.53	-1.63	.111
Standards knowledge—data collection and documentation	3.25	3.63	-1.41	.166
Applying gage control concepts	2.79	3.16	-1.47	.148
Gage control theory	2.93	3.25	-1.24	.222
Applying non-normal distribution theory	2.58	2.31	1.08	.287
Non-normal distribution theory	2.61	2.72	-0.43	.669
Note: t test of mean differences = 0 (vs. = 0).				
*Meets significance level with $\alpha = 0.05$.				

Figure 3. Combined chart for areas needing further attention.

should receive additional attention in technology-based programs. A bar chart was constructed to illustrate the difference in responses for industry professionals compared to college faculty. The chart shown in Figure 3 lists response differences in descending order of magnitude for all rank order data. The scoring for areas of study needing further attention was noticeably different between industry and faculty responses. Industry scored capability studies and SPC highest (most in need of further attention) while faculty members indicated SPC and design of experiments (DOE) should receive the highest priority. Both groups listed basic statistics among the top three items. Due to the scoring method and an unequal number of participants in the two groups, the raw score was converted to a percentage of the total possible score for each group. A means test was not feasible for the rank order portion of the results due to the complicated scoring method.

Analysis of Survey Results

The fact that recent graduates' overall skills in quality control were rated significantly lower by industrial professionals than by faculty members may indicate a disconnect between the two groups. Increased interaction and communication between the groups could be helpful in bridging this gap. The greatest differential was assigned to applying SPC skills. SPC is taught as a part of most technical programs and has been recognized as a key quality concept for decades. With great focus on this topic, it is troubling that such a gap exists between industry and faculty perceptions. Applying knowledge to industrial situations requires judgment

and experience that students often do not receive in the classroom. Although this reality is inevitable to some degree, additional classroom projects and laboratory exercises could help address the problem. Perceptions concerning graduates' understanding of SPC theory, knowledge of common equipment, ability to apply basic statistics, and ability to use equipment all indicated a statistically significant difference between industry and faculty ratings. Most of these abilities require the application and practice of theory. The survey results indicate that faculty members may need to focus much more on developing the practical, applied skills of students in order to meet industry expectations.

The rank order portion of the survey identified differences in ratings concerning areas of study needing further attention. Both industry and faculty strongly indicated that SPC and basic statistics should receive more attention in technology-based programs. Industry professionals identified capability studies as the most crucial area for additional coverage whereas faculty members' evaluation of this topic was much lower. The ability to perform and understand capability studies is a critical part of most quality control functions. Industry professionals seemed to indicate that specific, practical skills such as this are very valuable and need much more attention in the academic environment.

Faculty members indicated that DOE should receive much more attention in academic programs whereas industry professionals rated this area much lower. DOE has been touted, and used to a lesser extent, in industry for many

years. Being a more complex area of study, it requires a strong statistical background to be fully utilized. Many in industry who have taken DOE training may still lack the statistical skills to apply it effectively. This may explain the lower ranking assigned by industry; however, the importance of DOE has been clearly established. Montgomery (2001) and Roy (1990) have demonstrated the practical value of applying DOE in industry using various factorial techniques.

Analysis of Industry Concerns

The results of the survey reveal industry concerns and needs that should be further explored. If academic programs are to be improved, specific experiences and abilities that are lacking must be identified and integrated into industrial technology and engineering technology curricula. To address these issues, in-depth discussions with industry professionals were conducted. The issues identified during these discussions were very similar to those highlighted by the survey. In addition, a review of recent literature and teaching strategies was conducted. The conclusions drawn from these efforts follow.

Capability studies: The survey identified capability studies as a major area for improvement. An understanding of how to conduct and interpret these studies is a crucial basic skill in industry. Students are often exposed to the formulas and methods for calculating C_p and C_{pk} without gaining a clear understanding of the meaning and importance of the numbers being generated. Exposure to one-sided specifications, non-normal distributions from specific processes, and data collection methods as a part of process capability studies can help strengthen students' skills (T. Dorsey, personal communication, June 6, 2003).

Statistical process control: Both faculty and industry surveys indicated that SPC should receive more attention in technology-based programs. Most quality control courses include a study of SPC involving theory and textbook problem solving. This level of exposure may not require enough practice or development of applied skills as the industry survey indicated. Addressing applied skills in SPC provides an excellent opportunity for faculty members and students to interact with local industry. Student projects that involve interaction with local manufacturers and data collection from real process-

es can greatly increase applied skills (K. Hubbard, personal communication, March 10, 2004).

Relating process and product to quality:

Before any quality control study begins, a clear understanding should exist of the process and product from which the data are to be drawn. Most quality control training in the classroom includes statistical analysis, control charting, and basic procedures without emphasizing how characteristics of the particular process and product can influence the results. Without making this important link, opportunities for error and misinterpretation are endless. Errors involving incorrect subgrouping of data are particularly common in industry (Wise & Fair, 2001). Non-normal distributions are common among many processes such as the wear cycle associated with drilling processes (Oberg, Jones, Horton, & Fyffell, 2000). Exposing students to realistic process characteristics such as this example can strengthen their skills as they begin their careers (T. Dorsey, personal communication, June 6, 2003).

Gage repeatability and reproducibility:

When collecting data for analysis, assuring that accurate gages and gaging methods are used is a critical first step. Incorrect use of common measuring devices such as calipers and micrometers can be a particular problem (Hewson, O'Sullivan, & Stenning, 1996). Measuring equipment and processes must be well controlled and suited for the particular use in order to assure valid data collection (Little, 2001). Students who receive little or no practical experience with measuring devices have difficulty in understanding the seriousness of this issue. Given that inaccurate gages and gaging methods are common problems in industry, a strong argument can be made for strengthening gage control coverage at the college level (N. Anderson, personal communication, June 4, 2003). Hands-on projects involving gage repeatability and reproducibility (R&R) studies and gage control allow students to integrate knowledge with practical situations, strengthening needed skills in the process (Kemenade & Garre, 2000).

Standards for data collection and sampling:

Complying with appropriate sampling procedures and documentation practices is critical in most quality control studies. The sampling method should contain enough data to conduct a

complete analysis without the collection of unneeded information that distracts when drawing conclusions (Carey, 2002). An introduction to quality standards and procedures can help better prepare students to address issues such as correct sample size and sample identification, appropriate sampling procedure, and documentation requirements (N. Anderson, personal communication, June 4, 2003).

Recommendations

Based on the survey results, discussions with industry professionals, and literature review, the following recommendations are made concerning the improvement of quality control education:

- *Improve interaction between industry and academia.* The survey indicated a significant difference in responses from industrial professionals as compared to those from faculty members. Improved communication and exchange of ideas between the two groups is needed. By implementing an industrial advisory board, technology-based programs can take an important step toward this goal. Advisory boards made up of local and regional industry leaders can provide invaluable information concerning what is needed and expected of graduating students. This forum also allows faculty members to introduce ideas and methods that are not well known to industry. Other contacts with industry through student internships and funded research can be quite helpful in keeping the communication lines open. Industry interaction with student organizations through plant tours, guest speakers, and assistance with student projects can also prove beneficial.
- *Increase coverage of statistical process control and capability studies.* The survey strongly indicated that both industry and faculty recommend additional coverage of SPC and process capability analysis. Industry evaluation of recent graduates' applied SPC skills was particularly low. To compensate for this lack of applied skills, additional theory coverage should be combined with a "hands-on" laboratory component requiring process monitoring and interpretation. Realistic problems and complications associated with SPC and process capability that are likely to be experienced in industry should be discussed and included in assignments.
- *Emphasize the combination of practical application with theory.* The industry survey indicated significantly lower ratings for equipment knowledge, equipment use, applying basic statistics, and applying SPC as compared to the faculty survey. These applied skills appear to be lacking as graduates begin their careers. This shortfall can be improved by further emphasizing applied skills and practical application in combination with theory. Examples presented earlier that can lead to the development of applied skills include dealing with complications such as one-sided specifications, using common equipment to measure and collect data, conducting capability studies, SPC monitoring, performing gage R&R studies using real parts and data, and locating and using data collection and sampling standards. These few examples are representative of numerous opportunities for gaining practice and experience in applying theory. Many of these activities can be implemented in the classroom. If additional laboratory time is needed, it should be added into the curriculum.
- *Promote the introduction of new methods and techniques in industry.* New techniques and methods of analysis are often developed and perfected in academia, not industry. More complex methods of analysis and process improvement may not easily be introduced into industry. Although DOE techniques have been used for many years, they are still valued much more in academia than in industry according to the survey. These more advanced methods may require additional support and interaction with industry from college faculty, and may be further introduced by supplying graduates with significant training in these areas. Comments and opinions should not only flow down from industry to academia, but also flow up as education develops new or complex ideas and methods that can benefit industry.

Summary

Industry respondents evaluated recent graduates' knowledge and abilities in quality control

significantly lower than the same evaluation provided by college faculty. Industry professionals and college faculty have different opinions concerning which areas of study should be further emphasized to improve quality control education. By improving the dialogue and interaction between industry and academia and implementing a more applied education, the quality control component of industrial technology and engineering technology programs can be greatly strengthened.

Future Research

An important finding in this study was the disconnect between industry and academia concerning which quality control skills most need further emphasis in technology-based degrees. A comparison of student skills after completing

a more traditional lecture-based course versus a more applied course as suggested by this study would be of interest. This information could help determine the potential for improving quality control skills by revising course content and structure.

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Student Behaviors in the Context of Computer Aided Learning in Design and Technology Teacher Training

E. Stephanie Atkinson

Introduction

This article discusses the relationship among an individual's cognitive style, attitude to learning, and his or her achievement in the context of computer aided learning (CAL). The results of a small-scale study involving 32 students (18 male and 14 female) studying their first electronics module during an Initial Teacher Training (ITT) Design and Technology degree program at a university in England are reported. Data concerning cognitive style, gender, attitude to CAL, appropriate prior knowledge, and the test results from a unit of work that used a CAL package as the main teaching strategy are analyzed and the relationship between selected variables are discussed. Conclusions pertinent to the students in this study are then drawn.

Background

In all sectors of higher education (HE), there has been an increasing professional concern with the processes of teaching, learning, and assessment and their management, at a time when economic and technological changes have had a major impact (Dillon, 1998; Somekh, 1998). With the rapid growth in the power and functionality of modern computing and network systems, HE has been encouraged both at a national level and by locally driven initiatives to

embrace technology-assisted teaching and learning strategies (Boucher, 1998). In the context of this article, the technological changes referred to by Dillon (1998) are centered on the developing use of CAL packages to meet both lecturer and student needs within electronics modules in an ITT Design and Technology degree program.

The broad objectives for developing technology-assisted teaching and learning were first set out in 1996 after the Higher Education Funding Council for England (HEFCE) commissioned a six-month research study of information technology-assisted teaching and learning (ITATL) in HE. Primarily these objectives were to make teaching and learning more productive and efficient, to enhance the learning experience of students, and to widen access to HE through its delivery in new and different locations (Tearle, Davis, & Birbeck, 1998).

During recent years, a great variety of educational software has been designed that would support students' learning. Pedagogical advantages and disadvantages of such materials have been well researched (Alexander, 1995; Boucher, Davis, Dillon, Hobbs, & Tearle, 1997; Dillon, 1998; Ford, 1999; Lee, 1999; National Council for Education Technology [NCET], 2000; Pillay,

1998; Steurer, 1992). Benefits have been reported in terms of individualized learning that can be self-paced, self-accessed, asynchronous, synchronous, provide nonsequential based delivery, include positive motivational interactive features, while affording access to more accurate appraisal and documentation of learners' progress. Research has indicated that the hierarchical linking arrangements that facilitate browsing can also act as an aid to learning. The merging of formally separate media in a manner that allowed associations or links between the various elements (Ebersole, 1997) and under certain circumstances the modification of the form of the material being presented, by the learner themselves, have also been cited as positive features of CAL resources (Pillay, 1998; Steuer, 1992). At a time of considerable expansion in HE, the hope that Information and Communication Technology (ICT) could deliver a more cost effective teaching and learning environment has also played a significant role in its development (Somekh, 1998). However, there have been expectations without due regard to the difficulties that are an inevitable part of any technological innovation in education. Disadvantages have been cited (Ferris, 1999; Mak, 1995) in terms of the teachers' deficiency in understanding the differences between the pedagogy and philosophy underpinning the use of CAL and traditional learning materials in a university environment (Jones, 2001). There is also the lack of training for lecturers to exploit its potential (Oliver, 1994), and the need for appropriate technical support. In the context of the CAL materials themselves, many of the interfaces employed at present have been confusing and opaque to many users. For example, the absence of personal contact and clarity of message due to the nonexistence of physical presence, voice intonation, gesture, and other tacit cues (Harasim, 1989; Moore, 1992), together with the difficulty in conveying humor, irony, and subtle nuances of meaning (Feenburg, 1989), have all been shown to be disadvantageous for certain types of learners. It has also been shown that the nonlinear organization of information highlighted by many as an advantage has proved to be a distinct disadvantage for other users (Edwards & Hardman, 1989). Gygi (1990) referred to a lack of "discourse cues," whereas Shum (1990) talked of the

need to reduce cognitive overload for the user by designing better cognitive maps that would aid the user's navigation through the CAL materials.

Ebersole (1997) described designing effective interactive media as a daunting proposition. He explained that in addition to the collection and organization of useful content the designer of CAL materials must create a user interface that facilitates access to the content. He and others (Lord, 1998; Pillary, 1998; Recker, 1995) all believed that learning materials should be crafted with careful attention to the mental processes and learning style that the user was likely to employ. Learners have been seen to waste valuable time navigating an erratic course through the complex structure of the materials provided for them often because they have been unable to acquire the original author's structure and map it on to their own learning style (Alexander, 1995; Shum, 1990). It would therefore seem important that all learning materials, whether they are for traditional or CAL environments, should be cognitively well designed.

Just as an ergonomically designed chair is well adapted to the physical requirements of its user, so a cognitively ergonomic learning resource is well adapted to the learning requirements of its user. (Ford, 1999, p. 188)

The terms *cognitive style* and *learning style* have been widely used by educational theorists for the past 60 years. Terminology has varied from writer to writer (Curry, 1983; Dunn & Dunn, 1993; Riding & Cheema, 1991). On some occasions the terms have been used interchangeably, while at other times they have been afforded separate and distinct definitions (Cassidy, 2003). However, many (Biggs & Moore, 1993; Goldstein & Blackman, 1978; Riding & Pearson, 1994; Tennant, 1988; Witkin, Oltman, Raskin, & Karp, 1971) have agreed that cognitive style is a distinct and consistent way for an individual to encode, store, and perform, and one that is mainly independent of intelligence, whereas learning style "is adopted to reflect a concern with the application of cognitive style in a learning situation" (Cassidy, 2003, p. 81).

As the relevant research base on cognitive style has grown, so has the number of terms

used to describe cognitive style groupings. Riding and Rayner's (1998) analysis of the multiplicity of constructs concluded that the terms could all be grouped into two principal cognitive styles and a number of learning strategies. They referred to these cognitive style dimensions as a "Wholist-Analytic Cognitive Style Family" and a "Verbalizer-Imager Cognitive Style Family." The Wholist-Analytic style they defined as the tendency for individuals to process information in wholes or in parts, whereas the Verbalizer-Imager style they defined as the tendency for individuals to represent information during thinking verbally or pictorially. They believed that these dimensions were totally independent of one another.

Many notable investigations have been carried out concerning the relationship between cognitive style and ability. Witkin et al. (1977) differentiated between cognitive style and ability by emphasizing the bi-polar nature of cognitive styles, unlike intelligence and other abilities. They suggested that each pole of cognitive style had adaptive value under specified circumstances, whereas having more of an attribute such as intelligence was better than having less of it. This difference was well defined by Riding (1996). He explained that the basic distinction between cognitive style and ability was that performance on all tasks would improve as ability increased, whereas the effect of style on performance for an individual would either be positive or negative depending upon the nature of the task and the way in which it was presented to the learner.

In traditional teacher-led, paper-based environments, learning in matched conditions (instructional style matched to the student's preferred learning style) has been demonstrated to be significantly more effective than learning in mismatched conditions in many instances (Ford, 1999; Pask & Scott, 1972). Research findings using a sample of school children indicated that this was especially the case for young pupils and those of low ability. Conversely, more able pupils, who were given the opportunity to use mismatched learning materials at times, were shown to develop learning strategies that coped with a wider range of materials and experiences on future occasions (Riding & Rayner, 1999).

In the context of CAL environments, Ford (1999) suggested that it would be tempting to think that the potential navigational freedom inherent in such systems meant that mismatched education was a thing of the past, although he believed that the potential for navigational freedom was frequently not recognized by the learner nor were they always able, or willing, to use such freedom optimally, or even effectively, in relation to their preferred style of information processing.

Traditionally, learning materials in a university environment have been presented mainly in a text format. However, with the shift from an elite to a mass higher education system (Rumble, 1998) it has become increasingly important that materials are provided in a variety of forms that are able to match individual student learning style preferences. CAL packages, if designed to do so, have the potential to provide materials that can meet this need and be more sensitive to style differences.

The CAL package "units of learning" under consideration in this article were part of a suite of mixed media, blended learning materials developed over the past 25 years by LJ Technical Systems (www.ljgroup.com). These materials have been successfully and extensively used in schools and further education colleges across much of the world, particularly in America, the Middle East, and the United Kingdom (UK), although this was the first time a university in the UK had used these materials as part of one of its degree programs. The CAL package used in this instance had four primary objectives:

- Understanding electrical quantities and the use of instrumentation for their measurement.
- Identification of individual components and measurement of their characteristics.
- Synthesis of simple circuit building blocks based on components investigated.
- Location and identification of computer inserted "faults" within the investigated circuits.

The software was linked to a dedicated electronics base unit, and various subcircuit modules were connected to this for the investigations. All connections were by removable wires and link

pins, so no circuit construction skills were required. The tasks were presented in the form of an “on screen” manual but copies of this could be printed and retained by the students as a log-book of activities. The answers were entered in a separate window and took a variety of forms. These were predominately multiple choice, or yes/no question formats, but in some instances numeric answers were required. In the case of calculations, the system required the exact value for a mark to be awarded, but when entering measured quantities, any value within a certain range would be accepted because of component and instrumentation tolerances. Within a particular group of questions, the student was free to go back and alter an answer as often as necessary. However, students were unable to proceed to the next group until that section was submitted and marks allocated. Failure to achieve a certain minimum score would also prevent progression to the next stage and tutor intervention was then required.

The educational theorist would hope that the fundamental purpose of assessment is to give feedback to learners and thereby enrich their learning experience. In the past the culture and traditions of universities have been deeply rooted in enriching learning. However, recently there have been indications that the purpose of assessment in HE has changed. Factors such as government interventions, the massive increase in the numbers of students entering higher education, the change in the character and needs of the student population, the worsening staff-student ratios, the requirement for accountability, and clarity in the relationship between learning objectives, learning outcomes, and assessment criteria have all led to the development of a predominantly categorizing assessment culture within many universities.

Most of the investigations into the advantages of assessing students using ICT have assumed the educational theorists’ point of view, yet the use of CAL in university environments has brought the tensions between enriching learning and the need to categorize students into sharp focus. By their very nature, CAL-based systems are designed to facilitate the maximum number of positive outcomes for a cohort of students—be this by allowing repeated attempts

until the correct outcome is achieved, by offering unlimited time for grappling with the issues in hand before offering a response, or even by allowing group discussion of a problem before arriving at a consensus viewpoint. However, the very process of accommodating these differing learning strategies in this manner can generate relatively undifferentiated results for a cohort of students, with all of them achieving fairly high mark levels.

With the rapid growth in the use of CAL within university environments, and the research evidence to suggest that various factors could affect learning and achievement within that context, it seemed pertinent to the authors of this article to design a small-scale research project that could examine the relationship among attitude, cognitive style, learning, and achievement in the context of a CAL package that was being used to teach electronics.

Methods and Procedures

Sample and Components

The purposive nonprobability sample referred to in this article comprised the total 32 students (18 male and 14 female) studying their first electronics module during an ITT Design and Technology degree program at a university in England.

The following components were used:

1. **Cognitive Style.** A well-established cognitive styles analysis (CSA; Riding, 1991), which was computer presented and self-administered, was used. This indicated a student’s position on both the Wholist-Analytic (WA) and the Verbal-Imagery (VI) dimensions of cognitive style (Riding & Rayner, 1998) by means of an independent ratio for each. Every member of the sample carried out the CSA in the manner prescribed in the CSA administration documentation.
2. **Attitude to CAL.** The attitude of individual members of the sample to working with and using computers as a tool for learning was tested by means of a 58-item summated rating scale. Each of the items on the scale was subjected to a measurement of its discriminative power (DP). The 35 items with the highest DP

indices were selected to establish an attitude score for each student.

3. **Achievement.** One set of test results was used in this study. The test used was designed by LJ Systems and embedded in the CAL material. The overall mark for the module was calculated using the marks awarded for each task as described earlier in the article, together with a posttest which provided alternative scenarios that once again tested the learning that had taken place. As explained earlier, all the tests were computer generated and marked although they also required practical skills in creating the physical circuits and cognitive skills in linking the literature to the associated schematic diagrams, interpretation of instrumentation data, and the development of deductive reasoning to identify faults. The results were automatically summated and stored directly onto the computer managed learning (CML) system database. In line with university quality assurance requirements, all assignments were then both internally and externally cross-moderated to assess validity and reliability of both the marks and the materials being used. The students completed the module test before any of the other data for the study were collected.
4. **Prior Knowledge of Computing and Electronics.** A questionnaire that requested information regarding the previous computing and electronics experience of each student was used. Questions concerning computing and electronics were asked separately and involved examinations taken in computing and electronics prior to starting the degree program and any school or work experience in industry utilizing computing or electronics skills prior to starting the degree program. The answers were separated for scoring purposes into those that concerned previous experience in electronics and those that concerned previous experience in computing. A student who had studied an examination and had school or industrial experience in electronics or computing was given a score

of 2, whereas a student who had only experienced one of those situations was given a score of 1. A student with no experience of either situation was given a score of 0.

A student's perception of the newness of electronics and computing skills required to complete the module successfully was established through a second part of the questionnaire. This provided students with two statements, one regarding the newness of the electronics skills required in the module being studied and one about the newness of using computers for learning. These both needed a summated scale response. These were scored between 0 and 2. A score of 0 was given to those who indicated that all the materials were new to them, and also to those who said that they had not used a computer for learning before. A score of 1 was given to those who indicated that most of the materials were new to them, and also to those who said that they had sometimes used a computer for learning before. A score of 2 was given to those who indicated that little of the materials were new to them, and also to those who said that they had often used a computer for learning before.

5. **End of Module Feedback.** In line with all university modules, anonymous written feedback was collected from students using an optically read questionnaire. This feedback is primarily used to monitor the educational health of the module. However, it also provides the module leader with data on aspects of the module that students perceived as particularly helpful and areas of the module in which they believed their learning could have been enhanced if things had been approached differently.

Results and Discussion

Cognitive Style

Recent debate into the stability and internal consistency of many cognitive/learning style models (Coffield, Mosely, Ecclestone, & Hall, 2003; Peterson, Deary, & Austin, 2003; Riding, 2003) was taken into consideration when

methods of analyzing the collected data were designed. Initially, the data were analyzed using the raw CSA ratios as suggested by Peterson et al. (2003). However, no linear correlation with any of the variables under discussion was found, so it was decided to group the sample by the well used cognitive style categories defined in the CSA administration documentation, as these labels seemed appropriate to this research project. The WA ratios of the total sample ranged from 0.700 to 2.910 with a mean of 1.412 ($SD = 0.463$). The male and female means were, respectively, 1.392 ($SD = 0.475$) and 1.436 ($SD = 0.459$). The gender difference was not significant ($p = 0.7408$). The VI ratios ranged from 0.750 to 1.430 with a mean of 1.094 ($SD = 0.148$). The male and female means were, respectively, 1.096 ($SD = 0.143$) and 1.091 ($SD = 0.157$). The gender difference was not significant ($p = 0.9104$). The correlation between the two cognitive style dimensions was -0.153, attesting to the orthogonality of the two dimensions (cf. Riding & Cheema, 1991; Riding & Douglas, 1993). In comparison to the CSA standardization sample ($N = 999$) referred to by Riding (2000), the sample reported in this study had very similar mean scores on each dimension, both as a total sample and when divided by gender. However, the sample in this study did not have subjects at the extremes of either dimension. This was particularly noticeable at the Wholist end of the WA dimension and the Imager end of the VI dimension.

This later result was initially very surprising, as it had been expected that many of the sample would have been “strong” imagers because these students were training to become design and technology teachers where the need to be able to manipulate images in the mind during design activity was recognized as a valuable skill. However, as prospective teachers, the need to be able to work equally competently with both text and diagrams and be able to communicate with pupils at the extremes of a dimension would suggest that being at the center of a dimension could be an advantage. In this study, the categories on the VI dimension were fairly evenly divided into 9 Verbalizers towards one end of the dimension, 13 Bimodals around the center, and 10 Imagers towards the other end of

the dimension.

With regard to the WA dimension, in both the task of being a successful teacher and a successful design technologist, the authors would suggest that being strongly Analytic or Wholist could be an advantage at certain times and a disadvantage at others. Data from this study indicated that the sample on the WA dimension was unevenly balanced. It was predominantly Analytic ($n = 20$) with only 7 Intermediates around the center of the dimension and 5 Wholists at the other end of the dimension. It was therefore recognized by the researchers that this skewed distribution could affect results and needed to be borne in mind during data analysis.

Attitude to Using CAL

The data concerning student attitude to CAL was scrutinized using descriptive statistics. The maximum score that could have been achieved was 165 and the minimum was 35. The actual maximum score achieved was 153 and the minimum score was 69. The distribution was negatively skewed (skewness = -0.251) with an overall mean score of 117.281 and a standard deviation of 22.036.

When individual student scores for attitude were placed in rank order and split into equal sized quartiles (top, 2nd, 3rd, bottom) there was the expected significant difference between the mean attitude scores for each quartile.

There were no significant differences between the attitudes of male and female students to using computers for learning.

Achievement

The pass mark for the test was set high at 60% in order to try to overcome the problem highlighted earlier in this article concerning CAL's ability to facilitate the maximum number of positive outcomes and the need to differentiate between students' achievement within the electronics module. All students in the sample took the test and achieved a mean score of 73.938 with a standard deviation of 17.212. Six students failed and 10 students achieved scores of 90% or over. There was no significant difference between male and female students, although in both attitude to using computers as a

learning strategy and in the test results, females achieved lower mean scores than their male counterparts.

Previous Experience

All members of the sample provided their answers to the questionnaire regarding previous experience and newness of computing and electronics as described in the methods section of this article. In analyzing the data regarding previous computing activity, everyone in the sample had some previous experience of using computers although only six of the students had studied for an examination and used computers in an industrial context. It was therefore not surprising that 16 of the sample did not believe that they had had to learn any new computing skills in order to use a computer as a learning tool in this instance, whereas nine suggested that they had had to learn some new skills and seven had found that learning using a computer was very new to them.

With regard to previous electronics experience, a significant 28 students had no previous experience of electronics prior to starting their degree program, two had taken an examination or had industrial experience, and only two students had taken an examination and had industrial experience of electronics. It was therefore not surprising that a significant number of the sample believed that the electronics material was either entirely new to them or mostly new to them. Only four students believed there was little new material to learn.

The Relationship Between Variables

It was the intention of the authors to discuss the relationship between and among all the variables in the study. However, during analysis it became apparent that in certain combinations of the variables the cell size became too small for meaningful analysis to be carried out. The relationship between cognitive style and attitude to CAL; cognitive style and achievement; attitude, prior experience, and achievement were found to be statistically feasible. These are discussed in the following paragraphs. Issues associated with gender have also been included whenever the cell size permitted.

Cognitive Style and Attitude to CAL

When the two separate cognitive style dimensions were scrutinized in relation to attitude to CAL, there was found to be a significant difference between the mean scores for the three categories on the two dimensions ($p = < 0.0001$ in both instances). On the VI dimension, the largest difference was between Imagers and Verbalizers. Imagers were the most positive and Verbalizers the least positive. On the WA dimension, Wholists were the least positive and Intermediates, at the center of the dimension, the most positive. When comparing the two dimensions, it could be seen that Wholists were even less positive than Verbalizers in their attitude to CAL while Imagers were more positive than Intermediates.

This result would suggest that poor attitude to CAL may be influenced more by the segmented nature of the CAL materials than whether those materials were biased towards the use of images or text. However, it must be remembered that the skewed distribution of the sample on the WA dimension may or may not have influenced this result.

Cognitive Style and Achievement

When the two cognitive style dimensions were scrutinized separately in relation to test scores, there was found to be a significant difference between each category on both dimensions ($p = < .0001$ in both instances). Intermediates achieved a high mean score, while Wholists achieved a much lower mean score. On the other dimension, Verbalizers achieved the highest mean score and Bimodals, at the center of the dimension, the lowest. When the rank order for both attitude and achievement in the test were compared, it could be seen that on the WA dimension there was a positive relationship between the two variables. However, on the VI dimension Verbalizers were ranked lowest in attitude to CAL while they managed to achieve the highest mean score in the test.

Some explanation for the unexpected inverse relationship between Verbalizers' attitude and achievement was sought. An analysis of the CAL materials indicated that the balance between the pictorial and text based material remained relatively constant throughout and it

was felt that neither had a preponderance of sufficient significance to skew the outcomes. The explanation was thought to lie not so much in the way that the tasks were presented but more in the way that the content was organized. Quite complex text based instructions were designed to become much clearer when linked to their corresponding diagrams. The Verbalizer, in avoiding use of image and remaining focused on text, may have needed to read and re-read the material before gaining sufficient understanding to proceed. Such difficult and time consuming tasks may perhaps explain the resulting low CAL attitude scores, but this very investment of time in a task that they perceived as difficult may have led to a deeper understanding of the requirements and therefore the higher level of achievement.

Further examination of the VI data led the researchers to examine the possible reasons for the low mean score of Imagers in the context of their high attitude score. Such individuals could have been expected to have higher levels of satisfaction resulting from their focus on diagrams and the relative ease with which they were able to correctly build circuits from the visual information. Such activity one expected could have engendered the more positive attitude to CAL. However, the assessments required careful reading of accompanying text, which explained settings required before measurements could be taken and answers given. Those Imagers who were not as thorough in their attention to reading the text could therefore expect significantly lower scores as a result.

Attitude to CAL, Prior Experience and Newness of the Materials, and Achievement

When data concerning attitude to computing and previous experience and newness of electronics were combined, a positive relationship was found. Students who believed that there was little new electronic materials to learn had the most positive attitude to using computers in their quest for knowledge, while students who believed that all the material they had to learn was new to them were the least positive. The difference in attitude between the top and bottom groups was found to be significant ($\chi^2 = 61.350$, $p = <0.0001$). The anonymous "End of Module Feedback" supported a possible explanation for this outcome. Although the whole sample indi-

cated that they recognized the advantages that independent learning using CAL could offer, there was still a general feeling of resentment that the lecturer had not been "on call" for support when needed. Those with more experience of electronics naturally had a more secure mental "scaffolding" to support the leaps of intuition needed for progress beyond an impasse and such success seemed by its nature to have led to a degree of comfort in working with information technology (IT). Conversely, those with little electronics experience had no background to draw from to help maintain progress. Being unable to converse with the computer for the help needed led to an inevitable frustration with IT and the poorest attitude score.

When the test results were scrutinized with the student perception of the level of new electronic materials present in the CAL program as a second variable, it was found that the mean scores for those who found the materials new to them followed the expected pattern; they achieved the lowest mean marks. However, the mean marks for the other two groups were not as expected. Those who believed that there was little new material did not achieve as high a mean mark as those for whom the electronic materials were mainly new knowledge. Observation of the students while they were using the CAL materials suggested a reason for this. Many of the students who had not studied electronics before recognized their deficiencies and were prepared to invest the substantial amount of time needed to become cognizant. Their newly learned knowledge and understanding then led to success in the tests. Whereas many of those who believed that they already knew much of the electronics needed were seen to bypass the supporting materials available on the computer, moving directly to the tests. The weaker score for this group indicated that this confidence was generally misplaced.

When data from the questionnaire concerning students' personal level of computing experience prior to taking the electronics modules were analyzed in conjunction with attitude to CAL, the result once again indicated a significant positive linear correlation between the two variables (Fisher's r to z ; $p = .0032$). Those with previous computing experience were the most positive

and those with little computing experience were the least positive about having to use CAL to gain their electronic knowledge and understanding.

A further scrutiny of the data also indicated that there was a positive linear relationship between test results and the level of previous computing skills. Those with the most previous computing experience achieved the highest test results and those with little previous computing experience achieved the lowest result. In fact, when compared to the achievement data split by levels of prior electronic knowledge, it could be seen that levels of computing skills prior to the start of the module had a more marked effect upon achievement than the amount of electronics knowledge known before studying the module.

Conclusion

The evidence for this study was collected using a small purposive nonprobability sample. Consequently, it was not statistically possible to generalize to a larger population. However, the data gathered provided a useful picture of the relationship that existed between CAL materials, appropriate prior knowledge, cognitive style, and attitude to using computers as a learning tool, as well as ability to achieve when using such materials, for this specific cohort of students.

The data indicated that those students who had no previous electronics experience were significantly less positive in their attitude to using computers as a learning strategy in comparison to those who had prior skills in electronics. It was also found that there was a linear correlation between previous computer experience and attitude to using computers as a learning tool and previous computer experience and levels of achievement in the electronics test. The data from this study also indicated that computing skills were possibly more important for achieving high marks within the CAL situation under

consideration than the level of previous electronics knowledge.

With regard to gender differences, there was found to be no significant difference between male and female students in either their attitude to computing or in their levels of achievement when using the CAL materials under scrutiny, although in both instances males achieved a higher mean score than females.

With regard to the relationship between attitude, achievement, and cognitive style, it was unfortunate that the sample was not evenly distributed between the three categories on one of the two cognitive style dimensions. However, the results on the VI dimension, where the distribution of the sample was evenly spread, provided evidence to suggest that there was a different relationship between students' attitudes to using a computer as a learning strategy and their ability to achieve using such materials depending upon their cognitive style. The authors of this article suggest that CAL packages designed to present materials in a different manner to learners with different learning style preferences may well help those learners to achieve their full potential in terms of learning and achievement in comparison to software that does not have this facility.

The results of this research have also provided the stimulus for the authors of this article to continue collecting data from subsequent groups of students to see if these findings are replicated with a larger sample size that can add credence to the conclusions drawn from this initial small-scale study.

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The W. E. B. DuBois and Booker T. Washington Debate: Effects upon African American Roles in Engineering and Engineering Technology

Keith V. Johnson and Elwood Watson

The messages of Booker T. Washington and W. E. B. DuBois could not have been more diverse. The philosophical rivalry between Washington and DuBois has deep historical roots. To be on the same side fighting for the same purpose, progress, and uplifting of the Black race, these two Black intellectuals harbored radically divergent views on how to assist African Americans to free themselves from their often subhuman conditions. Both men were aware that technological advancement was of foremost importance to the advancement of African Americans. Washington's (1901) *Up From Slavery* and DuBois' (1903) *The Souls of Black Folks* were immediately hailed as classic commentary due to their efforts to address the then "Negro" problem in America. There were a number of Black Americans who made a valiant effort to mitigate poverty, illiteracy, racial discrimination, high mortality rates, and other des-

olate conditions that plagued many African Americans, particularly at the turn of the century. However, due to their influential appeal among certain constituencies, both Washington and DuBois garnered ample attention from many segments of the American intelligence, many of which were European in ethnic origin. Thus, acknowledgment from the White power structure (this was particularly true in the case of Washington) provided both men a platform to promote their message.

Washington was a student at Hampton Institute and became convinced that vocational education was the only means by which Blacks would become successful in America. In 1881 Washington went to Alabama and founded Tuskegee Institute, where he put into practice his belief that the ultimate solution to the race problem was for Blacks to prove themselves

worthy by becoming reliable and superior laborers, eventually making themselves indispensable to the economic well-being of the country. In order to accomplish this, Blacks needed the right form of education: an education that would be beneficial in an economic sense. Given his experience at Hampton, Washington felt that industrial education was superior to academic education for achieving his goal of Black social improvement (Spivey, 1978). As quoted in Franklin (1973), Washington believed that Black education “should be so directed that the greatest proportion of the mental strength of the masses will be brought to bear upon the everyday practical things of life, upon something that is needed to be done, and something which *they will be permitted to do* (emphasis added) in the community in which they reside” (p. 285). The basic philosophy of industrial education as practiced at Hampton and Tuskegee was quite simple. The training in various domestic and trade skills within an authoritarian and religiously based environment would produce a Black who would fit into the lower end of the occupational structure and, more important, know his or her place among Whites and come to accept that place as proper.

Such a form of education was just what White society sought. For Southerners, it would keep Blacks subservient and exploitable. For Northerners, it would serve as a way of calming racial tensions and providing a well-trained laboring underclass that could be used in the effort to industrialize the South. For these reasons, wealthy philanthropists in both the North and the South were willing to give large grants to institutions that adopted this vocational model while ignoring those institutions that remained academically oriented (Franklin, 1973; Quarles, 1969; Winston, 1971).

The results were as dramatic as they were devastating. The ideology of vocational education became the panacea for the race problem in America. Except for a few institutions of higher learning (Fisk, Atlanta, and Howard), Black colleges took the financial windfalls and adopted the vocational curriculum. Educationally, vocational training was a failure: It not only failed to prepare Blacks to move up in society, but it also guaranteed that they would move down. The emphasis on manual training and the trades served to destroy the educational aspirations that had been aroused during Reconstruction and wiped out the hope that education could

provide a way out of poverty. By 1930 industrial education was seen as a “cynical political strategy, not a sound educational policy” and proved to be the “great detour” for Blacks from which they are just beginning to return (Winston, 1971, p. 683).

Booker T. Washington was born a slave on the plantation of James Burroughs near Hale’s Ford, Virginia (Harlan, 1970). During the period of Washington’s prominence, from the 1890s until his death in 1915, probably the leading ideological orientation of American Negroes centered on the development of Negro business enterprise through a combination of thrift, industry, and racial solidarity, or Negro support of Negro business (Kusmer, 1991). Although the philosophy of “self-help” has largely been credited to Washington, this was a message that was very much in vogue as far back as the 1850s. It experienced a renaissance during Reconstruction, particularly among educated African Americans. The advocates of this progressive form of African American empowerment argued that African Americans, despite facing rampant discrimination, disenfranchisement, Jim Crow laws, and other forms of oppression, must turn from being defensive toward the capitalist system and adopt proactive methods of combating such a system. Once African Americans had proven their ability to help themselves and to acquire wealth and respectability, it was believed that prejudice and discrimination would disappear. During the mid 20th century, there were Black academics such as the late E. Franklin Frazier who argued that there were African American businessmen who were not above exploiting the masses of Blacks to augment their own economic welfare (Frazier, 1957).

At the close of the 19th century, the entrepreneurial class in the Black community depended in considerable part upon the support of White customers. Though the range of occupations varied from city to city, this group was composed primarily of blacksmiths, tailors, barbers, and other skilled artisans, hackmen and draymen, grocers, and less frequently meat dealers, hotel owners, caterers, real estate dealers, and contractors (Kusmer, 1991). Along with civil servants, teachers, pullman porters of upper class status, domestic servants in the most elite White families, the more eminent and better educated ministers, a few doctors, and an occasional lawyer, the more successful among

these entrepreneurs composed the upper echelon of the African American community in the late 19th century (DuBois, 1899).

By about 1900, however, significant economic and social changes were well under way. A growing antipathy on the part of Whites toward trading with Black businessmen coupled with rapid changes in technology and business organization forced many of these small entrepreneurs out of business. At the same time, the increasing urbanization of African Americans provided an economic base for professional and business men who were dependent on the services of African Americans (Meier, 1963). These services included banks, cemetery and realty associations, insurance enterprises, and numerous retail and service establishments (Meier, 1963). Previously established businesses such as newspapers, morticians, and retail merchants had depended upon the money that the upper middle class African American community had spent for their goods. By this juncture this economic class had increased in size. It was during the first two decades of the 20th century that two of the largest Black fortunes—that of R. R. Church, real estate magnet in Memphis, Tennessee, and Madame C. J. Walker, creator of the straightening comb and the first Black female millionaire—were created (Pierce, 1947). Walker was a profound example of early 20th century Black technological genius. It was the combination of the aforementioned factors of Black entrepreneurship that both Booker T. Washington and, to a lesser degree, W. E. B. DuBois attempted to espouse to the African American bourgeoisie (Meier, 1963).

Throughout American history, the Black upper class had an easier time obtaining an economic and technological based education than their brethren in the lower class. Because of this fact, they tended to be more acquainted with current scientific technology. Depending upon the city, the members of this socioeconomic class varied. In New Orleans the Black upper class consisted of free people of color. In Charleston, South Carolina, artisans, contractors, barbers, and postal employees represented the African American upper middle class. In cities such as Atlanta and Durham, there was a substantial entrepreneurial class that DuBois called the group economy. In Washington, DC, the situation was unique due to the large number of government workers and politicians. For many years (this was the case in many African

American communities, both urban and rural), ministers, teachers, and a few small businessmen (particularly after the Civil War) were the African Americans who were more inclined to gravitate toward technological pursuits (Meier, 1963).

Because of their diverse views on how to reduce the reductive circumstances of African Americans, both Washington and DuBois had viewed technology from different perspectives. Washington was a Southerner who harbored deep suspicion about the Black intellectuals who dwelt in the northern cities or attended the southern colleges that he never attended. He dismissed their arcane knowledge as too much from books and too little from life.

Washington was different than most Southerners in the fact that he was astute to the fact that in a capitalist society that it was pertinent for African Americans to become skillfully adept to the ever-changing economy. He knew that becoming technologically efficient was one such way to do so. This Black man who was the offspring of former Virginia slaves founded Tuskegee Institute in 1881. This was only four years after the Hayes/Tilden Compromise that officially ended Reconstruction in the South in 1877. Beginning with a few ramshackle buildings and a small sum from the state of Alabama, he built Tuskegee Institute into the best-known African American school in the nation. While not totally negating academic training, the school's curriculum stressed industrial education, training in specific skills and crafts that would prepare students for jobs. Washington built both his school and influence by tapping the generosity of Northern philanthropists, receiving donations from wealthy New Englanders and some of the leading industrialists and businessmen of his time, such as Andrew Carnegie, William H. Baldwin, Jr., Julius Rosenwald, and Robert C. Ogden.

Thus his establishment of Tuskegee Institute was the cornerstone for future goals that he harbored for African Americans. Washington's reputation as the principal of Tuskegee Institute grew through the late 1880s and 1890s; his school was considered the best exemplar of industrial education, viewed as the best method of training generations of African Americans who were either born into slavery or were the sons and daughters of freed slaves. His control of the purse strings of many of the

Northern donors to his school increased his influence with other African American schools in the South.

It was his legendary Atlanta Compromise speech that firmly defined Washington as a man who was deeply immersed with economic and technological advancement. It was during this speech that Washington urged African Americans to refrain from adamantly attempting to integrate with White America. Rather, he advocated a gradual emancipation of African Americans through hard work, economic improvement, and self-help (Washington, 1901). Technological advancement was an integral part of his message. His rhetoric gained universal acceptance among many Whites and a large number of Blacks.

What distinguished Washington from DuBois and many other African American leaders of the early 20th century was his philosophy that Black Americans had to keep ever faithful to the virtues of sacrifice, discipline, delayed gratification, and most important, economic salvation for their own communities.

The wisest among my race understand that agitation of social equality is the extremist folly, and that progress in the enjoyment of all the privileges that will come to us must be the result of severe and constant struggle rather than of artificial forcing. No race that has anything to contribute to the markets of the world is long in any degree ostracized. It is important and right that all privileges of law be ours, but it is vastly more important that we be prepared for the exercise of these privileges. The opportunity to earn a dollar in a factory just now is worth infinitely more than the opportunity to spend a dollar in an opera house. (Franklin & Starr, 1967, pp. 85-87)

Washington argued that business and technological acumen were paramount. This was the means by which the African American masses would prosper. He believed that cultured-based education was secondary and could be pursued at a later date.

DuBois concurred with Washington that progress among the Black race had to occur, but he believed that it would be more aptly served through a trickled down means. DuBois was born to a white French father, Alfred DuBois,

and Mary Burghart DuBois, a Black woman, in Great Barrington, Massachusetts, in 1869. He was what many people referred to in those days as “mulatto” or in contemporary terms, biracial. Unlike many Americans (Black or White) of the time period, his stellar educational opportunities afforded him a national platform for him to espouse his message. He earned his BA at Fisk University in 1888, another BA at Harvard in 1890, and later his doctorate in 1895. He was the first African American to earn a PhD at the institution (Aptheker, 1951). Ever determined to uplift Black Americans from poverty, he focused on how the skills of the Black professional class could be utilized to achieve this goal.

It was during this time period that the North was experiencing a large number of immigrants from Europe as well as a large number of African Americans migrating from the South. This fact provided for potentially volatile relationships between the newly arrived immigrants and the native born Black population. White Northern businessmen, primarily due to more familiarity and comfort with Europeans who shared their ancestral lineage, mores, and customs, began to align themselves with Jews, Greeks, Italians, and other White ethnics which, in turn, either marginalized or prohibited Black Americans from being able to provide services to their communities (Butler, 1991).

With regard to this problem, DuBois engaged in a major study of the city of Philadelphia. His work focused on four social classes within the city. The top 10% he called an upper class or aristocracy. These people included entrepreneurs and professional people. These people had decent jobs and their children attended the best schools. Group two was the respectable working class. These individuals were primarily made up of servants, waiters, porters, and laborers. This was a class that was eager to engage in upward mobility. The third group of African Americans was referred to as the poor. It was made up of recent immigrants who could not find work, unreliable persons, widows, and wives of broken families. The lowest class (about 6% of the Black population) was labeled as criminals (DuBois, 1899).

Because of the great discrepancies that existed between the two groups, upwardly mobile African Americans were able to successfully distinguish themselves among other

classes in the city. Class has often been used as a distinguishing feature of American society, especially among White Americans. However, it is also true that similar situations were commonplace among Black Americans as well. Upon his conclusion of studying African Americans in Philadelphia, DuBois decided that the only way that African Americans could advance was through the leadership of the upper classes. Thus the term talented tenth was adopted. DuBois was adamant in his belief that intellectual guidance from the best and brightest among the Black race was the means by which to advance African Americans. A number of years after Washington's death, DuBois (1940) reiterated his belief:

Since the controversy between myself and Mr. Washington has become historic, it deserves more careful statement than it has had hitherto, both as to the matters and the motives involved. There was first of all the ideological controversy. I believed in the higher education of a Talented Tenth who through their knowledge of modern culture could guide the American Negro into a higher civilization. I knew that without this the Negro would have to accept white leadership, and such leadership could not always be trusted to guide this group into self-realization and to its highest cultural possibilities. Mr. Washington, on the other hand, believed that the Negro as an efficient worker could gain wealth and that eventually through his ownership of capital he would be able to achieve a recognized place in American culture and could then educate his children as he might wish and develop his possibilities. For this reason he proposed to put the emphasis at present upon training in the skilled trades and encouragement in industry and common labor. (p. 70)

There was no doubt that by the early years of the 1900s that Washington's influence among the White elite was considerably stronger than DuBois'. There was no gainsaying his influence in the highest places, his manifold services to his people, and, above all, the radiating influ-

ence of Tuskegee's good works (Lewis, 1993).

Washington's leadership ultimately gave way to new forces in the 20th century, which placed less emphasis on individual leadership and more on organizational power. The founding of the National Association for the Advancement of Colored People (NAACP) in 1909 with W. E. B. DuBois as its first president and the National Urban League in 1911 challenged Washington's power as a dispenser of political patronage as well as his technological and economic message. Nevertheless, he remained active as a speaker until his death in 1915 at Tuskegee.

DuBois had a phenomenally prolific career as a writer and scholar. Over time, he became more disillusioned with America, particularly the Black elite—the group that he dubbed as the Black upper class—believing that they had failed on their obligation to lead the masses of African Americans out of retrograde circumstances. In October 1961 he moved to Ghana. In 1963 he renounced his American citizenship and officially became a citizen of Ghana. He died there on August 27, 1963, at the age of 95 and was buried there (Rampersad, 1976).

Both men were aware that the need for African Americans to become technologically literate was paramount. However, whereas Washington advocated a hands-on external approach, DuBois promoted a paternalistic form of advancement of the Black race. Both men's philosophies are still being argued and applied in the technological arena today.

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A Multiple-Regression Model for Monitoring Tool Wear with a Dynamometer in Milling Operations

Jacob C. Chen and Joseph C. Chen

Introduction

A major goal of the manufacturing industry is increasing product quality. The quality of a product is strongly associated with the condition of the cutting tool that produced it. Catching poor tool conditions early in the production will help reduce defects. However, with current CNC technology, manufacturers still rely mainly on the operator's experience to operate and monitor machines to avoid defects from poor tool conditions. Since operator experience can be unreliable, recent research has focused on integrating a tool condition monitoring system within the machine to allow online, real-time monitoring to reduce the dependence on human judgment.

Any effective monitoring system must be able to sense tool conditions, allow for effective tool change strategies when tools deteriorate, and maintain proper cutting conditions throughout the process (Lee, Kim, & Lee, 1996). Among the many possible machining conditions that could be monitored, tool wear is the most critical for ensuring uninterrupted machining.

The traditional process for predicting the life of a machine tool involves Taylor's (1906) equation $VT^n = C$, where V is cutting speed, T is tool life, and n and C are coefficients. This equation has played an important role in machining tool development (Kattan & Currie, 1996). Since advanced machining was introduced in the mid-1900s, various tool wear monitoring methods have been proposed to expand the scope and complexity of Taylor's equation. However, none of these extensions has been successfully adopted in industry universally due to the complex nature of the machining process. Therefore, there have been many attempts to explore other more promising methods for monitoring tool wear online using computers and sensing techniques (Atlas, Ostendorf, & Bernard, 2000; Li & Tzeng, 2000; Pai, Nagabhushana, & Rao, 2001; Roth & Pandit, 1999; Wilkinson, Reuben, & Jones, 1999). Again, none of the in-process monitoring systems has ever been applied in any form in industry because research is still at the estimation stage; the systems are too immature to implement for monitoring (Waurzyniak, 2001).

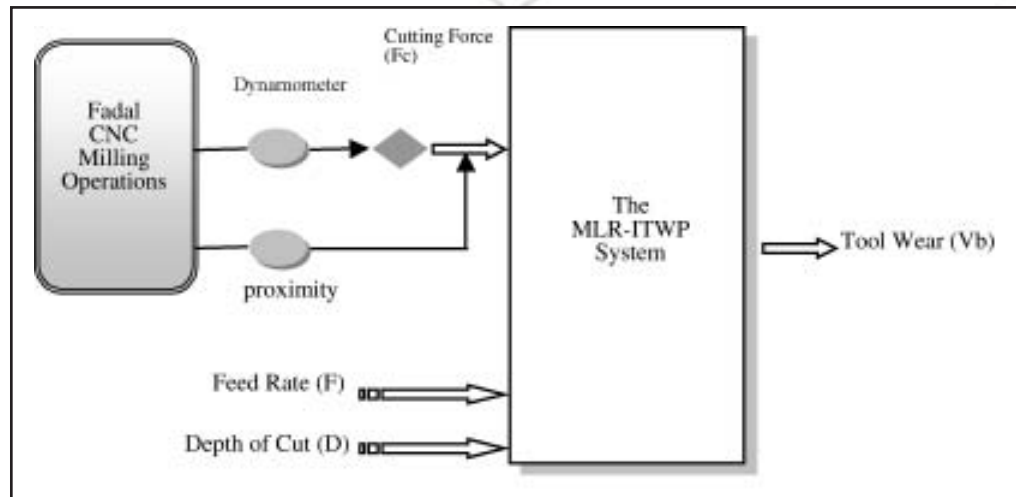
Therefore, researchers saw a need to explore an experimental and statistical approach in developing an in-process tool wear monitoring (ITWM) system. In order to accomplish this goal, this ITWM system requires an integration of sensing and decision-making techniques. For any in-process machining monitoring system, the sensing techniques are used to give the machine the capability of "seeing" that is equivalent to the human's eyes. However, the signals from the sensor have to be processed in order to determine whether or not something abnormal has occurred. The decision-making techniques are developed for the purpose of processing the signals from the sensors and data from other resources to determine whether or not the machining is satisfactory. Therefore, the decision-making techniques function like the "brain" of machines to make them intelligent.

Studies in the past have shown that the dynamometer sensor was much more effective than any other sensors in the field of tool wear (Dutta, Kiran, & Paul, 2000; Wilkinson et al., 1999). However, cutting force is very complex—it varies in different directions and varies throughout the whole revolution of the spindle. As a result, when tool wear occurs, it is sensible to conduct a cutting force analysis experimentally and statistically to find the cutting force representation that best predicts tool wear.

There is no doubt that the dynamometer is the most effective sensor available for monitoring tool wear. However, past studies of building tool wear prediction systems have used different decision mechanisms—either classic mathematical equations (Cho, Choi, & Lee, 2000; Sarhan, Sayed, Nassr, & El-Zahry, 2001) or expert systems (Dutta et al., 2000; Susanto & Chen, 2002)—based on different interests. In this study, a multiple regression approach was used as the decision mechanism in the proposed ITWM system.

Purpose of Study

The purpose of this study was to develop an ITWM system using cutting force as a sensing signal and integrating the multiple regression approach as the decision mechanism. In order

Figure 1. The architecture of the MLR-ITWP system.

to develop the proposed ITWM system, the following two research outcomes were expected:

1. Identify the cutting force representation that could best predict tool wear.
2. Build and test an in-process tool wear prediction system, which was a multiple-regression model in this study, with the cutting force identified from the first task.

Architecture of In-Process Tool Wear Prediction System

In this study, the ITWM system that integrated multiple-linear regression can be named the multiple-linear-regression-based in-process tool wear prediction (MLR-ITWP) system. The input variables were feed rate (F), depth of cut (D), and cutting force (F_c), while the only output variable was tool wear (V_b). The architecture of the MLR-ITWP system is illustrated in Figure 1.

In the MLR-ITWP system, the three inputs entered the system as follows: both feed rate and depth of cut were controlled and programmed into the Fadal machine, while cutting force signals were collected through a dynamometer and converted to digital format through an A/D (analog/digital) converter. The digitized cutting force data per revolution of the spindle were simplified to a representative value, which was selected based on the force analysis. The following section shows the experimental setup for the study.

Experimental Setup

The experimental setup is illustrated in

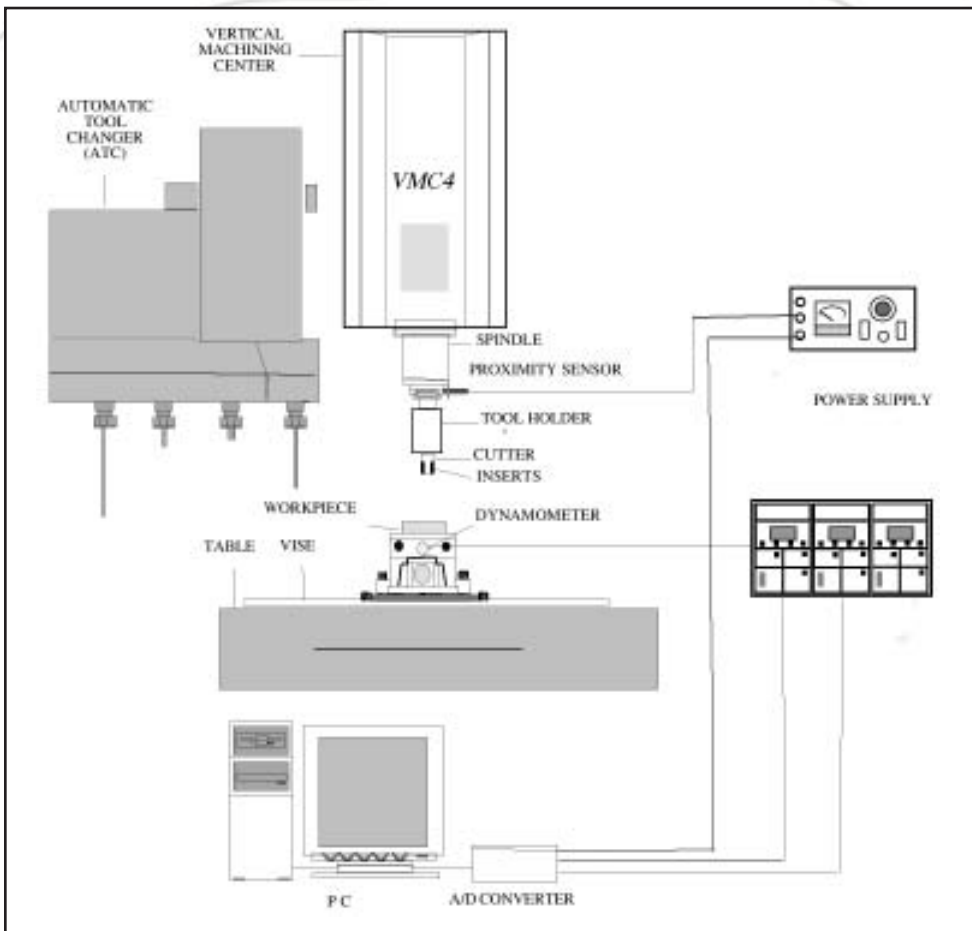
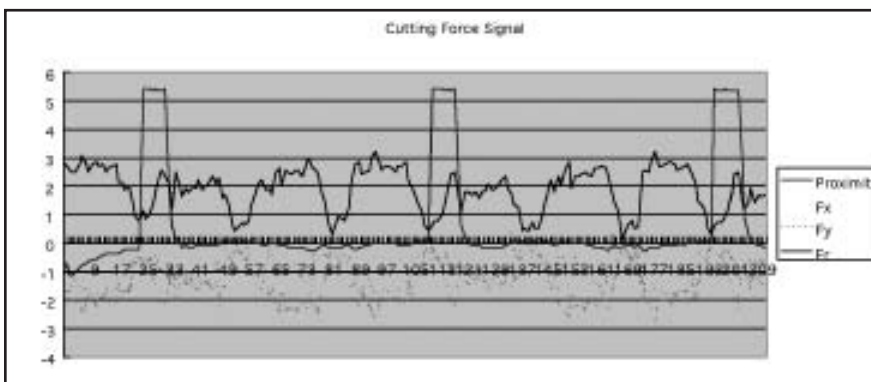
Figure 2. The dynamometer sensor was mounted on the feeding table of the Fadal vertical machining center with the workpieces/tool holder on top of the sensor. The proximity sensor was mounted on the spindle and connected to a power supply. Through an A/D converter, the signals from both sensors were collected and converted into digital codes on the computer.

Hardware

Two sensors were used in the study: a Kistler 9257B type dynamometer sensor, which is capable of detecting force signals in three orthogonal directions (F_x , F_y , and F_z), and a Micro Switch 922 series 3-wire DC proximity sensor, which is used to determine the starting point of each revolution of the spindle in the force diagram (see Figure 3). Together, these two sensors were used to determine the cutting force magnitude.

An RCA WP-703A power supply was used to provide about 2.5V of electromotive force to operate the proximity sensor. A Kistler Type 5010 amplifier was used to amplify the force signals from the dynamometer to the maximum of 10V. An Omega CIO-DAS-1602/12 A/D converter was used to convert cutting force data from analog to digital. A P5 133 personal computer was used to collect data from the A/D converter, which originated from the proximity sensor and the dynamometer sensor.

The workpiece material used in the study was 1018 steel. A VNE90-1250C 3-insert mill with 1.25" cut diameter was used to hold inserts. APKT 160408R coated carbide inserts

Figure 2. Experimental setup.**Figure 3. An example of cutting force signal converted as collectable digital data.**

were mounted on the tool holder for the milling machining. A Meiji EMZ-5TR Zoom Stereo Microscope was used to observe and measure the flank wears on the inserts.

Identifying the Best-Predicting Cutting Force Representation

The goal of the first experimental run and data analysis was for force analysis, in order to identify the best cutting force representation for predicting tool wear.

Force Analysis Experiment

The first part of the study included determining the cutting force representation to be recorded and entered into the prediction system in the second part of the study.

Past experiments have revealed that in end-milling operations, the Z direction (the vertical direction) of the cutting force can be ignored because it is insignificant relative to tool wear

monitoring compared to the X and Y orthogonal directions. Therefore, the selection of the force directions was limited to the forces in the X and Y directions and the resultant force of the two: F_x , F_y , and F_r , where $F_r = \sqrt{F_x^2 + F_y^2}$.

For each of these three directions of cutting force, one could identify two possible cutting force representations: average force (\bar{F}) and average peak force (\hat{F}). Therefore, six cutting force representations were identified:

$$\bar{F}_x = \frac{\sum_{i=1}^m |F_x^i|}{m}$$

$$\bar{F}_y = \frac{\sum_{i=1}^m |F_y^i|}{m}$$

$$\bar{F}_r = \frac{\sum_{i=1}^m F_r^i}{m}$$

$$\hat{F}_x = \sum_{k=0}^{n-1} \left\{ \text{Max}\{|F_x^i|\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

$$\hat{F}_y = \sum_{k=0}^{n-1} \left\{ \text{Max}\{|F_y^i|\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

$$\hat{F}_r = \sum_{k=0}^{n-1} \left\{ \text{Max}\{F_r^i\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

In the equations, m is the total number of cutting force signals collected in a revolution, and n is the number of the mill inserts (in the study, $n = 3$).

To decide the best cutting force representation for predicting tool wear, the only independent variable was the flank wear (Vb) of the tool, and the only dependent variable was the cutting force. The remaining cutting conditions were set to fixed values: feed rate = 5 in/min, spindle speed = 1800 rpm, and depth of cut = 0.05 inches.

Figure 4. A typical flank wear geometry on an edge of an insert.

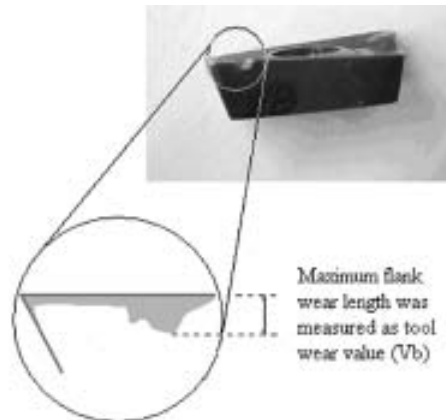
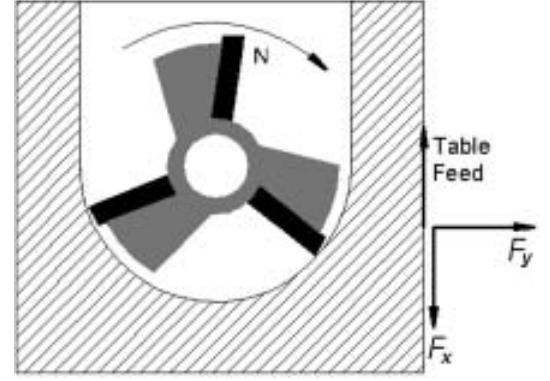


Figure 5. Definition of cutting force directions.



Correlations of Six Cutting Force Combinations and Tool Wear

One of the easiest ways to identify the best cutting force representation out of the six was to compare the correlations of these cutting force combinations and tool wear. The correlation coefficients were determined using Microsoft Excel, and the formula for the correlation coefficients is:

$$1) \quad \rho_{Vb-Fc^k} = \frac{\sum_{i=1}^n (Vb_i - \bar{Vb})(Fc_i^k - \bar{Fc}^k)}{\sqrt{\sum_{i=1}^n (Vb_i - \bar{Vb})^2 \sum_{i=1}^n (Fc_i^k - \bar{Fc}^k)^2}}$$

where ρ_{Vb-Fc^k} is the correlation coefficient between tool wear (Vb) and cutting force combination k (Fc^k); Vb_i is the tool wear value of the i^{th} cut, while n is the total number of the training data sets. In this study, $n = 13$, $\bar{Vb} = \sum_{i=1}^n Vb_i / n$ and $\bar{Fc}^k = \sum_{i=1}^n Fc_i^k / n$.

With six cutting force combinations, six different correlation coefficients were obtained: $\rho_{Vb-\bar{F}_x}$, $\rho_{Vb-\bar{F}_y}$, $\rho_{Vb-\bar{F}_r}$, $\rho_{Vb-\hat{F}_x}$, $\rho_{Vb-\hat{F}_y}$, and $\rho_{Vb-\hat{F}_r}$. The largest correlation coefficient among the six indicates that the correlation is the greatest and the cutting force combination in that correlation is the best to predict tool wear.

Results of Force Analysis

From the analysis (please contact the authors for the details), it can be concluded that the average peak forces in one revolution in the Y direction had the greatest correlation coefficient (0.78) with a p value of 0.002. However, the Y direction here is from the dynamometer, which is oriented differently from the machine. Therefore, the Y direction in this study is better defined as the direction perpendicular to the direction of the table feed (see Figure 5). The theoretical reasons, although not included in the study, definitely merit further study in the future.

Developing the MLR-ITWP System

After the best cutting force representation for predicting tool wear had been identified as the average peak forces in one revolution in the Y direction (\hat{F}_y), all the input values for the MLR-ITWP system were clearly defined. The second run of experiments and data analyses were then conducted.

Tool Wear Monitoring Experiment

Cutting Condition Selection

General cutting conditions usually refer to three major cutting parameters: feed rate, spindle speed, and depth of cut. From the body of research concerning tool wear (Lin & Lin, 1996; Susanto & Chen, 2002), spindle speed was not a significant factor in predicting tool wear. To simplify the study, spindle speed was therefore fixed in the study; only feed rate and depth of cut varied. The values of the cutting conditions were as follows:

Feed rate (x4): 5, 7, 9, 11,
and 13 inches/minute

Depth of cut (x3): 0.02, 0.03,
0.04, 0.05, and 0.06 inches

Spindle speed: 1,200 rpm

Tool Wear

In the beginning of the experiment, all of the tool wears of the industry-used inserts were classified into five range groups (0.20-0.29, 0.30-0.39, 0.40-0.49, 0.50-0.59, and 0.60-0.69 mm), with the first group considered the lightest wear and the last group the heaviest wear. During the experiment, two sets of the inserts in the 0.60-0.69 mm group were worn out quickly and fractured in the third cut, which was quite different from the other inserts (which remained almost intact during the experiment). For this reason, it could be concluded that the tool life ends for this kind of coated carbide insert when it reaches the wear range of 0.60 mm.

Because many more industry-used inserts broke during the experiment with no replacements available, the researchers decided to artificially grind new inserts to the appropriate level of wear. In the study, the inserts were finely ground to even artificial tool wear with values of 0.25, 0.35, 0.45 and 0.55 mm (the 0.60 mm tool wear limit was observed).

Experimental Design

With two factors from the cutting condition and one factor from the tool wear, the experimental design was a factorial design with three

factors: feed rate (x5), depth of cut (x5), and tool wear (x4). Therefore, 100 experiments were needed for the purpose of training the monitoring system. The data to be collected were the cutting forces (that is, the best predicting cutting force representation concluded from the first part of the study: the average peak forces in the Y direction).

Results of Monitoring Tool Wear

The multiple-linear-regression model of tool wear, the MLR-ITWP system in Figure 1, was built with the help of the statistical software package JMP. The regression model considers the interactions among these three factors in the analysis, according to the following equation:

$$Vb = \beta_0 + \beta_1 F + \beta_2 D + \beta_3 Fc + \beta_4 F*D + \beta_5 D*Fc + \beta_6 Fc*F + \beta_7 F*D*Fc$$

Where Vb = tool wear (flank); F = feed rate; D = depth of cut; \hat{F}_y = cutting force (the most significant force representation revealed previously); and β_i ($i = 0, 1, \dots, 7$) = the coefficients to be decided.

Using the JMP software, all the coefficients β_i in the model were decided, and the following regression model was obtained:

$$Vb = 0.1615 + 0.0454*F + 5.965*D - 0.0429*Fc + 0.1397*F*D - 0.0781*F*Fc - 8.2053*D*Fc + 1.3551*F*D*Fc$$

The analysis of variance of the regression model showed that the F ratio was smaller than .0001, which shows that this model is very significant for predicting tool wear.

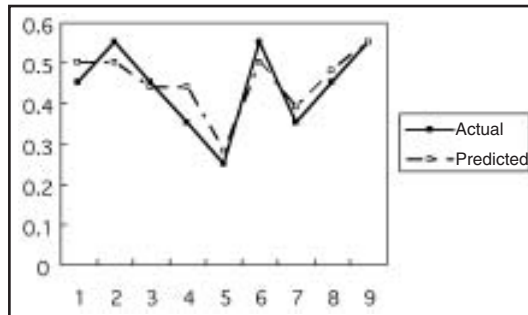
Verification of the MLR-ITWP System

Once the regression model was formed, the MLR-ITWP system was built. To evaluate the performance of the developed system, nine sets of data were used for testing. The testing data sets were different from the 100 sets of training data used to produce the regression models.

The actual tool wear and the tool wear predicted with the testing data through the regression model were then compared. Nine sets of testing data were used to compare the actual wear with the predicted wear. The average error is ± 0.039 mm.

Figure 6 compares predicted and measured tool wear magnitude for all nine test cuts. The results suggest that the proposed MLR-ITWP system reasonably predicted tool wear in an online, real-time fashion.

Figure 6. The comparisons of the actual and predicted tool wears.



Conclusions

A new in-process tool wear prediction (MLR-ITWP) system in milling operations has been set up, developed, and examined. The system showed the capability of predicting tool wear during the machining process.

The conclusions of this study are summarized as follows:

1. The average peak forces in the Y direction in a revolution best predict the tool wear among the force directions and the modes considered in the current study.
2. This proposed MLR-ITWP system can predict the tool wear value to have average error of ± 0.039 mm compared with the actual tool wear.
3. The proposed ITWP system has some limitations, which suggest the following possible directions for further research:
 - a. The tool wear used for developing the system was changed from industry produced to artificially ground. The difference between the two wears needs further study.
 - b. During the experiment, the researchers found that tool wear prediction is strongly affected by

the existence of tool chatter.

Therefore, the study of chatter prediction and control is also necessary for the development of automated machining.

- c. A MLR model has the limitation that it lacks the capability to learn—it does not allow any future data inputs. It is valuable to explore tools such as SPC, EMP, and DOE to assist in overcoming the problem in the future research.
- d. A MLR model is limited in its ability to simulate complex, nonlinear phenomena. Other ITWM systems that employ expert systems as decision mechanisms have value for future research.
- e. This research is limited to one type of tool insert and one type of workpiece material. Enlarging this system to include more cutting tools and materials for workpieces could make the results of this line of research more practical for implementation in industry.

In summary, this study provides the authors with a better position in continuing the tool monitoring system to enable an automated machining process for more efficient manufacturing in the future.

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Holistic Assessment of Students in Undergraduate Industrial Technology Programs

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

“External constituents are demanding not only that departments say they are doing good things and not only that they measure how hard they are trying, but also that they measure outcomes” (Walvoord et al., 2000). “[Colleges] should be focused on the ‘value added’ of the student experience. In today’s society, the need to educate for understanding—not just grades—has never been more important” (Morrow, 2004). “What counts most is what students DO in college, not who they are, or where they go to college, or what their grades are” (Edgerton as cited in Morrow, 2004).

As evidenced by these quotations, the nature and assessment of education is changing significantly, and the assessment trajectory is away from sole reliance on the traditional perspective of student grades. Technology faculty must respond to the changing requirements of student assessment and ensure that graduates of the program meet both the expectations and standards of the institution as well as those of other stakeholders, particularly the private sector that typically employs those graduates.

We are reevaluating ways in which students in their departments are assessed. The three-step “backward design” process recommended by Wiggins and McTighe (1998) has served as a conceptual framework and useful design perspective. Broadly, these steps condense to (a) identify desired results, (b) determine acceptable evidence, and (c) plan learning experiences and instruction. Wiggins and McTighe offered a number of practical guidelines to the design and development of curricula, including the assessment process. They stated that “the backward design approach encourages us to think about a unit or course in terms of the collected assessment evidence needed to document and validate that the desired learning has been achieved, so that the course is not just content to be covered or a series of learning activities” (p. 12).

We have identified a number of elements driving assessments at the departmental level as well as those that address the degree candidates’ needs. We have explored non-classroom-cen-

tered assessment methods and have collected and analyzed preliminary data towards reaching the goal of more holistic assessment of student progression. The planning, work, and outcomes to date that support the learning goals and expected outcomes set forth by stakeholders follow. However, a point of reference must be set prior to any attempt to address the dual issues of student and program assessment by industrial technology faculty in higher education. For example, consistent with both our experiences and the recommendations outlined in step one of the three-step “backward design” process, one must have a fairly specific vision of the knowledge, skills, and attitudes a technology student should develop prior to embarking on his or her career before formulating an assessment plan. In other words, what is to be assessed? This might include such things as knowledge of technology and its associated processes; practical skills associated with materials, tools, processes, and systems related to technology; ethics related to technology development and application; attitudes toward technology; and issues impacting student learning.

A clear understanding of the reasons for assessing technology students is also critical. These reasons may originate in basic requirements to uncover information regarding students’ knowledge, skills, or attitudes. One may wish to verify that students can demonstrate practical technology skills and related professional skills, or one may desire to motivate and enhance learning. Ultimately, it is a goal of the faculty to have more than just course grades to reflect student performance. As noted by Wiggins and McTighe (1998), “Too often as teachers, we rely on only one or two types of assessment, then compound that error by concentrating on those aspects of the curriculum that are most easily tested by multiple-choice or short answer items” (p. 65). A well-structured program should include assessment by a variety of methods and from a more holistic perspective than is often currently employed. An ancillary benefit of a more holistic assessment may be a more positive student attitude toward the discipline.

From the departmental perspective, improved student assessment allows faculty to do a better job evaluating and adjusting the technology curricula and program options (e.g., manufacturing and occupational safety) to meet educational objectives. Improved assessment also increases faculty credibility with other stakeholders in the educational process, such as administration, parents, and employers. Given a clear understanding of the overall educational objectives and forces driving the need for assessment, one may turn to questions of available assessment strategies and benefits they provide for the learner and the instructor.

We three authors formed an action research collaborative with the central goal being to develop, implement, and evaluate innovative forms of assessment that document student growth in a holistic manner. The alternative forms of assessment that we advance are not envisioned as wholesale replacements for existing knowledge-based tests; rather, we suggest they supplement existing grade data with assessments targeted toward technological capability and problem solving. Outcomes of an improved assessment process allow faculty to make adjustments to both curricula and extracurricular activities with greater clarity regarding the impact of such changes on the industrial technology program and students. Ultimately, the faculty hope to accelerate the students' learning more effectively and efficiently and "jumpstart" them into their profession.

Technology Learning Community

Changes to assessment processes are complicated by simultaneous changes to the program. For example, the context for our action research is a Technology "Learning Community" (TLC) that we established within the industrial technology curriculum at Iowa State University. Learning communities are relatively recent additions to the landscape of American universities. Research by Lenning and Ebbers (1999) has indicated improved student retention and satisfaction with the academic experience through the use of learning communities. The TLC is an induction and support activity for freshmen and transfer students in the industrial technology program. The purpose of the TLC is to help entering students (regardless of their academic stage) maximize their educational experience and begin their professional acculturation within the discipline of industrial tech-

nology. TLC participants are organized into small groups of students. Each student group works with a peer mentor, an industrial mentor (an industrial technologist practicing in industry), a graduate assistant, the academic advisor, and industrial technology faculty members. In addition to more formal assessments, TLC students evaluate their experience each week in reflective summaries. Below are some comments selected from TLC students' summaries:

- This was a very helpful class since it provided to me a strong idea of what I can expect, and in turn what is expected of me. Peer mentor groups met in class and we exchanged phone #'s and E-mail addresses.
- Last class we had speakers come in from SME [Society of Manufacturing Engineers], ASSE [American Society of Safety Engineers], and SPE [Society of Plastics Engineers] clubs who talked about what their organizations do and how to get involved in these clubs. I think this was a very good class day because most people are unaware of how they can get involved in something like this and what they actually do in these clubs. I am very interested in SME and hope to join next fall. I would have liked to join this semester but with my current schedule and obligations this is impossible.
- Last week our group met with our peer mentor for half an hour. We talked about our schedules and how classes are going. Our peer mentor suggested that we do our resumes and turn them in to him the next time we meet. We discussed how important it is to go to Career Day on Feb 19th. He wants our resumes so he can go over them and make possible corrections so we can have them with us for career day. We have assigned a day and time for our meetings, which is Wed. at 5 p.m. in the TLC room.
- Last week's class helped me to more fully understand the full potential that an Industrial Technology major could provide for me in the future. In our group meeting we talked about how to improve our resumes and how to sign up for ECS [Engineering Career Services].

At the end of each semester, TLC students were asked to evaluate the ability of the TLC experience to meet the goals of the TLC initiative using *excellent*, *good*, *fair*, or *poor* ratings. When questioned about their experiences with respect to the goals of “Orientation to the industrial technology discipline and profession” and the “Process of developing realistic self-assessments, career goals,” 93% of the students reported *good/excellent*. The responses were even more positive regarding the goals of “Connections with faculty, other students, and industry professionals” and the “Process of introducing the variety of professional roles available through an industrial technology degree,” with 96% of the students reporting *good/excellent* experiences.

The experiences within the introductory course were crafted to establish both the small group cohesiveness and interaction with peers that is so essential to effective team-based technological problem solving that employers demand of industrial technology (ITEC) graduates. Another key to the success of the TLC is the use of industrial mentors. ITEC students are very pragmatic—most have their sights set firmly on a career in industry. Hence, inputs from industrial mentors are highly valued and persuasive. They convey high expectations while demonstrating realistic practice and applications in industry.

Student learning has been enhanced through cooperative interaction with their TLC group members and mentoring team. The industrial and peer mentors have increased the TLC students’ understanding of the discipline and the importance of curriculum components beyond what individual faculty members can accomplish in the classroom. The TLC students have a better understanding of their personal learning styles and how that impacts their studying habits and classroom interactions. By the end of the semester, TLC students have generated or updated their resumes, started professional portfolios, and set the foundation of team building and awareness of technology that they will continue to enhance and build upon throughout their academic career and beyond. Additional information regarding the Iowa State University TLC may be found in Freeman, Field, and Dyrenfurth (2001).

Student Outcomes Assessment

Desired student outcomes include enhanced

capability with technology, increased student satisfaction, higher academic performance, refined career goals, and a greater awareness of one’s learning style and how to most effectively utilize that information. When students conclude their studies within technology programs, it would be desirable for them to have indicators of capability to demonstrate academic proficiency, beyond just course grades.

In order to assess student outcomes in a more holistic way, appropriate instruments must be available. Efforts are underway to identify and evaluate such instruments for use in the undergraduate industrial technology curricula. In addition to the qualitative and quantitative analyses related to the TLC, activities include an evaluation of the use of Dyrenfurth’s (1991) technological literacy instrument based on the work reported in Dyrenfurth and Kozak (1991), the ACT Work Keys employability skills exams, and the National Association of Industrial Technology (NAIT) certification exam; reviews of each student’s portfolio by faculty and an industrial team; and comparison of participant satisfaction and academic performance with other students not participating in TLC activities.

A number of other key targets have been included as initial assessment areas. These targets include student demographics, academic performance, learning styles, technological understanding and capability, and ethical dimensions of technology.

With these assessments, faculty hope to benchmark both the initial and exit competence of students, document students’ progression over the course of their academic experiences, document differences among groups and types of students, and investigate implications arising from these differences for program design and development. The assessments are also designed to focus attention on the various components of competence (e.g., technical, managerial, foundational, personal) and to increase attention to the assessment process in order to strengthen its validity and reliability.

The faculty has synthesized a set of targeted industrial technology competencies for students at Iowa State University through the efforts of individual instructors responsible for specific courses, the departmental curriculum committee, and other stakeholders

(e.g., Industrial Advisory Council and NAIT). It would be advantageous for faculty to be able to collect a wide variety of demographic data and longitudinal data for tracking student performance, as well as data indicating performance against desired outcomes; however, they recognize that constraints exist on the amount of data that can be collected and analyzed.

The NAIT accredits industrial technology programs. Department missions are expected to be compatible with the approved definition of industrial technology. The mission, as listed in the 2002 *NAIT Self Study Report* (Department of Industrial Education and Technology, 2002), states: "The Department of Industrial Education and Technology at Iowa State University prepares technically oriented professionals to provide leadership in manufacturing technology and occupational safety through an undergraduate industrial technology program" (p. 6.2-2).

A second necessary, but not sufficient, condition for accreditation listed in the 2002 *NAIT Self Study Report* requires that competencies shall be identified that are relevant to employment opportunities available to graduates. While the accreditation process serves as one driving force for curriculum review and outcomes assessment, there are others. Apart from the expected continuous improvement efforts of the faculty, the department retains an Industrial Advisory Council to assure that the industrial technology curriculum addresses the current and future needs of business and industry. The Council recommends and reviews curriculum and program changes that will enable the department to be responsive to business and industry (Department of Industrial Education and Technology, 1998). The department faculty, NAIT, and the Industrial Advisory Council all play an important role in defining and refining the competencies expected of industrial technology graduates.

Ultimately, a reevaluation and alignment of course content offered in the programs was needed to ensure that the competencies expected of industrial technology graduates were realized. This involved a comparison of curricular content with required NAIT objectives. Gaps and/or superfluous material were identified and addressed. Faculty members led this effort, but they were not without guidance with respect to the process. The aforementioned three-step design process by Wiggins and McTighe (1998)

and work by Kenealy and Skaar (1997) offered useful frameworks. Kenealy and Skaar suggested an interesting outcomes-defined curriculum renewal process that has continued to influence this effort. Kenealy and Skaar described a multi-step "action planning" process that has been adapted so that a large number of diverse faculty and students could contribute cooperatively and with a sense of ownership. The needs of clientele groups led to the definition of major educational outcomes for the program, which in turn formed the foundation for learning experiences that would serve to meet student needs. Kenealy and Skaar stated that by grouping learning experiences, course titles and objectives are defined for a renewed curriculum. Subsequently, courses are defined by specific learner competencies, which are edited for proper sequencing. They also examined cognitive learning skills to ensure that upper level skills were represented throughout the curriculum.

Assessment Instruments

Assessment instruments exist that are appropriate and readily available and for which validity and reliability studies are already well documented. We entered into discussions with ACT, Inc., regarding the use of the Work Keys® system at the undergraduate level. This is a system designed to quantitatively measure certain employability skills. It includes job profiling and work-related assessments and serves a variety of needs in the industrial and educational arenas. For example, the test component of the Work Keys system is designed to assess personal skill levels in important areas of employability skills (ACT, 1997). There are currently eight tests: (a) applied mathematics, (b) applied technology, (c) listening, (d) locating information, (e) observation, (f) reading for information, (g) teamwork, and (h) writing. ACT (1997) stated that educators can use the Work Keys information to develop appropriate curricula and instruction that target skills needed in the workplace. The Work Keys instruments have extensive reliability and validity studies completed (ACT, 1997) at the secondary level, but little information was available demonstrating that its use could be extended to the baccalaureate level. Our preliminary research results with undergraduates would seem to warrant additional investigation of the Work Keys system. Five of the eight tests were administered to undergraduates, including (a) applied mathematics, (b) applied technology, (c) locating information,

(d) teamwork, and (e) writing. Our primary concern was that a majority of the students would score at the highest scale level of the exams, thus diminishing the usefulness of the exams for assessment purposes at the baccalaureate level. This did not prove to be the case as only 9.1% ($n = 33$) achieved this level in the Applied Technology exam, 14.8% ($n = 27$) achieved this level in the Locating Information exam, and no students achieved the highest level in the Teamwork and Writing exams ($n = 26$ and $n = 22$, respectively). Applied Mathematics yielded the only exam where significant numbers of students (45.2%, $n = 31$) scored at the highest level.

The ITEC program enrolls numerous transfer students from engineering. Many of these students have not had a great deal of academic success in the engineering program, but most seem to thrive in the industrial technology program. It has been posited that a mismatch between instructional style and learning style has been a leading cause of at least some of these students' previous academic problems and that a change to a more "hands-on" curriculum has allowed them to flourish. While there may indeed be systemic differences in the instructional approaches taken by engineering and industrial technology faculty, a recent study undertaken to investigate this question found that there were no statistically significant differences in learning styles between groups of engineering students and industrial technology students at either Iowa State University or North Carolina A & T State University (Fazarro, 2001). Fazarro used the Productivity Environmental Preference Survey to evaluate learning style differences (Dunn, Dunn, & Price, 1996).

A number of other planned assessment instruments require some additional development prior to their wholesale use. Some are lacking sufficient reliability and validity data, whereas some offer only partial coverage of desired content areas. For example, the NAIT certification test currently covers only four technology categories: (a) production planning and control, (b) safety, (c) quality control, and (d) management and supervision. There are other topics that fall under the technology umbrella such as materials and processing, industrial training and development, energy, instrumentation and control, and information technology. Rowe (2001) suggested an updated test blueprint for the NAIT certification exam. Rowe

used a modified Delphi technique to identify core content, subject areas, and competencies. Thirteen core competency areas were identified including (a) leadership skills for supervisors, (b) teamwork, (c) fundamentals of management, (d) safety management, (e) technical graphics/CADD, (f) quality, (g) electronics, (h) human resource management, (i) technical writing, (j) written communication, (k) verbal communication, (l) computer integrated manufacturing, and (m) manufacturing automation. Rowe's findings indicated a need for expanding the use of written and verbal information, particularly with respect to communicating technical information.

The current NAIT certification test is a cognitive, norm-based, multiple-choice test. It contains four 40-question subsections: production planning and control, quality control, safety, and management/supervision. Summary statistics, including classical difficulty and discrimination coefficients (point biserial correlation) based on a sample size of approximately 1,200 students, are available from the authors. Efforts are also underway to analyze these exam items using item response theory (IRT) methods. There appears to be a significant level of interest by NAIT-accredited programs for use of the certification exam in both program and student evaluations.

Description and sequencing of the test construction process (preparing test specifications, item construction and review, detecting item bias, estimating reliability, etc.) are readily available in, for example, Crocker and Algina (1986). All tests used for assessment are expected to pass a review against generally accepted test construction guidelines.

Other instruments currently under consideration include Dyrenfurth's (1991) technology literacy test, a survey of attitudes toward technology (DeVries, Dugger, & Bame, 1993; Raat & DeVries, 1986), multiple technological problem-solving appraisals developed in the manner suggested by Kimbell and Stables (1999), and the assessment of technology projects and activities using group process and student individualized performance rubrics suggested by Custer, Valesey, and Burke (2001).

We envisioned the deployment of the aforementioned assessment instruments across the department and longitudinally over the students' four-year period of study. The plan would have

the department's faculty establish a database of specific course goals and objectives and then crosswalk each to the department outcomes. Existing tests and other assessments would be cross-indexed to these goals and objectives. Tables of specification would be used to identify weighting and/or coverage gaps, inappropriate proportions, etc.

Subsequently, innovative assessment mechanisms, such as authentic assessments, portfolios, rubrics, and adaptive testing, would be expanded to complement and/or modify the current assessment strategies. Some authentic assessment activities are currently in place in the industrial technology program at Iowa State University. Freeman and Field (1999) discussed assignments given to groups of safety students that involve job safety analyses, along with equipment and process reviews in labs run for manufacturing students. These assignments are identical to the tasks safety students might find when working in an industrial setting following graduation. Students have also been asked, for example, to develop and construct tooling for specific tasks in metallic materials and processes labs. Many of these laboratory-based activities offer opportunities for authentic assessment.

Multiple-choice assessments will be subject to item analysis and will be recorded in the item database. These assessments have their place as tests of technological knowledge; however, Kimbell and Stables (1999) do not consider them to be valid tests of technological problem solving. Kimbell and Stables offer a great deal of insight into the development of performance assessment instruments for technological problem solving and the development of assessment rubrics to translate performance qualities into numeric data for statistical analysis.

A summary listing of the anticipated system development activities are shown below:

- Conceptualize outcomes based on inputs from faculty, NAIT, and the Advisory Council.
- Analyze objectives for each course in program.
- Analyze NAIT certification examination table of specifications.
- Crosswalk course outcomes to objectives.
- Crosswalk objectives to NAIT certification examination table of specifications and exams for each course.
- Select instruments:

- Conduct additional literature review.
- Review American Educational Research Association presentations.
- Explore available tests or identify and develop appropriate new instruments.
- Define benchmarking process.
- Finalize assessment timing.
- Develop assessment-sampling matrix that secures data, which may then be aggregated without imposing all tests on all students.
- Bring test administration and analysis online through the use of off-the-shelf software.
- Develop analysis plan.

Student performance will also be recorded in a database and, within legal guidelines and pending student approval, certain elements of the information will be available to assist peer and industrial mentors in conducting discussions with students. Peer and industrial mentors will be expected to offer each student constructive perspectives as to how his or her performance is progressing against personal and professional standards. Assessment validation will involve the program's industrial advisory council members so that real-world standards are not only employed but are also made clear to students. A key goal is to demonstrate student awareness of growth over time. Potentially confidential topics from a student perspective will be handled through discussions with faculty and faculty mentors.

Summary

There are clear and persistent indicators that changes are needed and expected in our system of education. In 1999, the National Research Council reported, "The goals and expectations for schooling have changed quite dramatically during the past century, and new goals suggest the need to rethink such questions as what is taught, how it is taught, and how students are assessed" (pp. 152-153). In 2001, the Council reviewed and expanded on trends, which "are changing expectations for student learning and the assessment of that learning" (National Research Council, 2001, p. 22). Efforts to design and implement a more holistic assessment of students in industrial technology programs are certainly timely and in keeping with the spirit of the recommendations by the National Research Council and others. Our work represents an initial step towards

capitalizing on some of the innovation that, while important, nevertheless reflects singular enhancements. Our goal was also to integrate several of these innovations into a more systematic approach. To this end, we have conceptualized a framework for moving forward, we have established the feasibility of using the Work Keys® employability skills instrumentation, and we have described some necessary implementation steps. We invite members of the profession to join in the challenge of implementation of such enhanced systems of assessment.

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Technologies Applied in the Toshka Project of Egypt

Wafeek S. Wahby

Background

The Toshka Project, located in Egypt (see Figure 1), involves excavating a canal to carry about 380 billion ft³ of water every year from Lake Nasser to the Toshka Depression, southwest of Aswan. This will eventually create a new valley to the River Nile in the western desert of Egypt in addition to the currently existing prehistoric river course. Before discussing the Toshka Project, it is important to first identify the following (see Figure 2):

- Toshka Region
- Toshka City
- Toshka Depression (in Arabic: *Mon-kha-fadd Toshka*)
- Toshka Bay (*Khore Toshka*)
- Toshka Spillway (*Ma-feed Toshka*)
- Toshka Canal (*Sheikh Za-yed Canal*)

The *Toshka Region* is located southwest of Aswan, about 600 miles south of Cairo. *Toshka City* is a new metropolitan city that is planned to serve a future population of 5 million. *Toshka Depression* is a natural depression in that area with an average diameter of 14 miles and a storage capacity of 1,665 billion ft³. *Toshka Bay* is a shoot off Lake Nasser towards Toshka. *Toshka Spillway* is a free spillway discharging the water of Lake Nasser when it exceeds its highest stor-

age level of 620 ft. It is a 14-mile long, man-made canal connecting Toshka Bay with the Toshka Depression and works as a safety valve for Lake Nasser, upstream of the High Dam.

Toshka Canal is the heart and soul of the Toshka Project. It is a new canal conveying the excess water of Lake Nasser that is pumped into it through a giant pumping station that elevates the water about 175 ft. The water then flows through the canal to reclaim and irrigate 534,000 new acres in the western desert of Egypt (El-Hag-Gar, 2001). The Toshka Project is an integral part of a much larger, mega project, the Southern Valley Development Project (SVDP), that aims at doubling the amount of cultivated land in Upper Egypt through developing the Toshka, East El-O-Wee-Nat, and the New Valley Oases (Ministry of Water Resources and Irrigation, 2000).

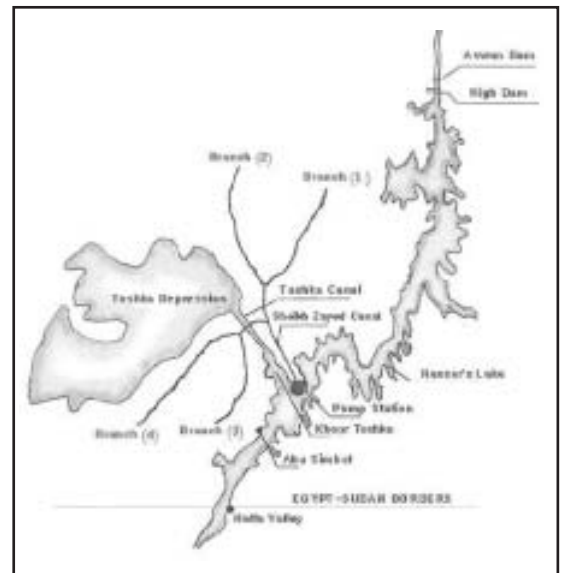
The Southern Valley Development Project

The SVDP is *not* a mere irrigation or agricultural project. The SVDP is a multifaceted, multiphase, development project that mainly involves horizontal expansion and land reclamation projects in the southern part of the Nile Valley in Egypt. It is a national, integrated,

Figure 1. Egypt.



Figure 2. The Toshka Project (Younan, 2001).



massive development project, aiming mainly at creating a balanced, re-organized Egyptian map from the demographic, habitation, economic, and security points of view. Total investments for implementing this project by 2017 are estimated at some US\$ 100 billion, of which 20% to 25% is pledged by the Egyptian government to construct the main canal and its four off-shoots, the pumping station, major roads, and main electricity network. The remaining 75% to 80% is to be supplied by the private sector.

Agriculture in the SVDP is only a base for the integrated development planned. Industry, mining, alternative energy production—and possibly oil and gas production and storage—and tourism are other parts of the vision, with plans for desert safaris, car rallies, conferences, and medical tourism.

Objectives of the SVDP include:

1. Adding new areas of agricultural land lying in the Southern Valley region.
2. Establishing new agricultural and industrial communities based on the exploitation of the agricultural raw material available in the new land.
3. Attracting and retaining a workforce, thus gradually dealing with the problem of overpopulation in the old Nile Valley.
4. Constructing an efficient network of main and side roads in accordance with the development objectives and plans.
5. Promoting tourist activities in such regions rich in ancient monuments.

The Toshka Project Infrastructure

The Toshka Project infrastructure includes the main pumping station (*Mubarak pumping station*), the Toshka Canal, water production wells and artificial charging, and wind and sand storm breakers (Wahby, 2001).

Mubarak Pumping Station (MPS)

The Toshka Project begins with the main pumping station—also known as *Mubarak pumping station (MPS)*—located on the left bank (west) of Lake Nasser, and north of Toshka Bay. More specifically, the pumping station is located 5 miles north of Toshka Bay spillway canal, 28 miles south of intersection with the Abu-Simbel/Aswan main highway. From this intersection it is 133 miles to Aswan northward and 37 miles to Abu Simbel southward. When completed, it will deliver 12,000 ft³/sec into the main feeding canal.

The construction of the pumping station has been undertaken by the European Egyptian Japanese Consortium and led by London-based Skanska Cementation International. Engineering group ABB was awarded the contract to supply all the electrical equipment by Japanese Hitachi (part of the European Egyptian Japanese Consortium) in 1998. The contract included the high-capacity frequency converters for the pump motors (Water Technology, 2003).

The multistage MPS is one of the world's largest, designed to have a maximum static head of about 175 ft, which guarantees its operation when the water level in Lake Nasser reaches its lowest level of storage (445 ft; Abdel-Rahman, 2001). SonTek/YSI has provided the Toshka Project with four Argonaut-SLs to continuously record and display flow and level data for day-to-day operation of the canals. Data will also be logged and used as a historical record for a mathematical model that will give optimal set points for the canal water level (Sontek, 2002). Twenty-four pumps (12 each side), each with a discharge capacity of 600 ft³/sec, are being housed inside the pumping station. The maximum energy necessary to operate MPS during maximum lifting is 375 M.W.

The station will be fed with 11 kV electrical power through a transmission line from a substation constructed close to the 11 kV switchgear building that is linked to the electric power double 220 kV line from Aswan High Dam with a length of 160 miles. The MPS is also an integral part of a concurrent project called the New Valley Development Project (NVDP), aimed at establishing an agro-industrial development in an adjacent area of about 988,000 acres.

Loughborough-based Morris Material Handling supplied five cranes having the combined qualities of size and flexibility required by the MPS project: three cranes with a capacity of 130t for lifting pumps and two smaller 30t gate cranes, each with a lift height of approximately 180 ft. One 130t goliath and the two 30t “odd-leg” goliaths were mounted on top of the completed pumping station. The 130t goliath lifts the pumps from the pump room to the loading bay, and the two 30t odd leg goliaths lift gates within the station. The two 130t overhead traveling pump room cranes started operation on site in mid-2001 with the other three cranes being installed on top of the pumping station at

the end of 2002. These 5-500 series cranes were chosen because of their versatility to meet varying customers' requirements. Built on-site, the cranes for this project were designed and manufactured in the UK, with Morris staff commissioning the machines on-site in Egypt (Water Technology, 2003).

Under a turnkey lump sum contract, with operation supervision during a guarantee period of 48 months, the MPS includes the design, construction, and maintenance of the following:

- An intake channel, 3 miles long, conveying water from Lake Nasser to the suction basin of the pumping station. Part of the channel (1 mile) is dry excavation (volume of excavation is 187 million ft³), and the rest (2 miles) is wet excavation (volume of excavation is 196 million ft³). The wet excavation is done using three gigantic dredgers (the world's largest at 200 ft arm length) for excavation under water.
- A reinforced concrete pumping station having length x width x height dimensions of 462 x 132 x 231 ft located as an island in the center of the suction basin. The lower 165 ft of its height will be permanently submerged underwater. Project designers for the concrete structure are Germany's Lahmeyer International and Cairo-based Hamza Associates.
- Twenty-four discharge concrete ducts having width x height dimensions of 9 x 8 ft, delivering the water from the pumps to the Toshka Canal via the discharge basin.
- Two annex buildings housing the 11 kV switchgear and the diesel generators.
- Three workshops: electrical workshop with laboratory, mechanical workshop, and automotive workshop.

Groundbreaking of the Toshka Project took place on January 1998, and excavation work at the MPS site started on June 1, 1998. The station was scheduled to be completed in 2002 at a cost of US\$ 400 million. However, on January 12, 2003 during the celebrations of the 5th anniversary of the project's groundbreaking, only two pumps were put to work in a test operation with symbolic power enough to let water fill limited parts of the new Toshka Canal, only to a modest depth.

The Toshka Canal

The Toshka Canal is the main canal of the project, having a length of 44 miles that branches into four subcanals, with a total length of 160 miles. The canal and its four subcanals are designed to carry a discharge of 900 million ft³/day to reclaim and irrigate four areas: 118,600 acres, 118,600 acres, 198,000 acres, and 98,800 acres, respectively—totaling 534,000 acres, an area equivalent to the combined areas of three neighboring governorates: Aswan, Kena, and So-Haag (Ministry of Water Resources and Irrigation, 1999).

The maximum designed water depth in the canal is 20 ft and the bed width is 100 ft, with a longitudinal slope of 6.67 inches/mile. The side slopes of the canal are 2:1, making the width at its top 200 ft. While the evaporation from the canal is estimated to be 0.7%, its cross-section is being lined with dense concrete to prevent any water leakage. After excavation to the required section, an 8-inch thick layer of stabilized soil (a compacted sand/cement mixture) is placed. Before pouring the top 8 inches of padding concrete layer onto that sub-base, 0.04 inches thick polyethylene sheets are placed on top of the sub-base stabilized soil layer to completely cover and "seal" it. A total of over 200 million ft² of polyethylene sheets are expected to be used in that process (Ramsis, 2001).

Two huge aggregate excavating and processing systems have been constructed and are able to supply coarse and fine size aggregates for concrete mixing. With the addition of two other concrete batching plant systems, the concrete production rate could reach 86,000 ft³ per hour, which can satisfy the capability of 20 million ft³ per month concrete placing. Each batching plant has its own cooling system that guarantees a 45°F temperature for cooling concrete, even in extremely hot weather (Taha, 2001).

To date, 70 miles have been completely excavated, of which 25 miles have already been also padded. The strict commitment to the workplan helped in complying with the schedule set for concrete-padding works, even under extremely unfavorable weather conditions. The usual operating rates amount to more than 370 longitudinal feet per day. However, in some instances it exceeded 430 longitudinal feet per day. When finished, the Toshka Canal is

expected to have utilized over 40 million ft³ of concrete. Quality assurance and quality control procedures guarantee that code requirements, technical specifications, proper work practices, and safety measures are rigorously followed in all engineering works.

Water Production Wells and Artificial Charging

Currently, water required for various applications is supplied through the available groundwater stored in the local aquifer. Along the main canal, five productive wells were constructed to irrigate about 740 acres. However, to fully utilize the available ground water, another 200 wells are being dug to serve an area of about 29,600 acres.

Meanwhile, the Egyptian Ground Water Research Institute (GWRI) carried out studies to use the excess in floodwater, discharged to the Toshka Depression since 1996-97, to charge the Nubian ground aquifer. Artificial charging is now being carried out with an expected initial cost of about US\$ 3 million.

Wind and Sand Storm Breakers

Wind and sand storm breakers comprising two rows of kaya and ponsiana trees are being planted on each side of the main canal as well as its four branches to protect them from the wind and the sand storms that ravage this region throughout the year. Almost 65 miles of trees have been planted to date (Abol-Hag-Gag, 2001).

Data and Statistics

Total excavation work in the Toshka Project is estimated at 3,100 million ft³—seven times that which was needed in the construction of Aswan High Dam (only 445 million ft³). To date, about 2,700 million ft³ of excavation work is complete. As for sand filling work, 290 million ft³ out of 540 million ft³ has been accomplished.

Basalt and gravel for concrete work are provided locally from the Toshka area, whereas sand is transported from the nearby Kom-Ombo (65 miles) and the cement from Ass-Yoot (220 miles). Patching plants are located at 3-mile intervals, and eight mixing units produce over 37,000 ft³ per day. Special chemical additives are incorporated into the water used for mixing and curing concrete to keep its temperature at 45°F.

Currently, five companies are working on the site using seven padding machines to pad the sloping sides and the short horizontal parts at the berm and the bed levels (Kadry, 2001). The bottom segment of the canal padding is manually lined using mechanical concrete mixers, pumps, and vibrators for concrete placement.

To serve ongoing reclamation projects, the area is equipped with an electric power grid and an excellent network of roads. Over 90 miles of new passageways and asphalt roads, besides another 375 miles of rehabilitated roads, were completed, which form an efficient and vital communication and transportation network (Hass-san, 2001).

The Toshka Project Controversy

The Toshka Project has attracted the attention of many individuals and groups in Egypt as well as worldwide and created much controversy on whether it is a mirage or marvel (El-Khodari, 2000). Some are very enthusiastic and optimistic about it, to the extent of calling it “The New Delta Project” or “The Inverted Pyramid Project.” On the other hand, the Toshka Project also has fierce critics, ranging from environmentalists worried about its demands on Nile water to economists who question its profitability.

Advantages of the Toshka Project include:

1. Dealing with the complex problems arising from skyrocketing population growth in Egypt that include jobs, food, housing, health, education, and transportation.
2. Doubling the amount of cultivated land in Upper Egypt.
3. Utilizing the massive amounts of water stored in Lake Nasser.
4. Facilitating power generation projects.
5. Offering venues for navigation and waterway transportation.
6. Promoting and developing fishery, tourism, and recreational activities.
7. Reaching new areas with fresh water and creating favorable conditions for the south-to-northwest water transfer.
8. May yield new archeological discoveries.
9. Relieving Lake Nasser from silt accumulating on its bed since the building of Aswan High Dam in the 1960s and

alleviating its negative effects on the lake's capacity as well as the High Dam's stability.

10. Construction of the new Toshka City that would serve a population of 5 million to relieve the overcrowded old valley.
11. Yielding botanical and animal resources that can be utilized in several pharmaceutical and fish-processing industries.
12. Developing an environment in the area of the new project to attract wild birds and animals.
13. Including solar and wind energy development used in generating clean electrical power to meet expected demand.

Disadvantages of the Toshka Project include:

1. Egypt is pouring money into desert reclamation—wasted finances that could have been used more productively in other urgent needs such as health care, housing, and education.
2. This project, in addition to other concurrent mega-projects in Egypt, is causing liquidity and cash flow crises by sucking the lifeblood out of the economy.
3. Poor cost-benefit analysis of the project.
4. Historically, Egyptians resist moving from their homes to new settlements in the desert, and the Toshka Project is no exception.
5. Unrealistic water resources management by diverting water badly needed in the traditionally most fertile land of the Nile Valley.
6. Egypt could even run short of water if other Nile basin countries to the south should build dams and divert some of the flow.
7. The negative effects this project may have on the River Nile ecology, particularly on wildlife, groundwater table level, irrigation, urbanization, and pollution.

The Future

A minimum of 720 billion ft³/year of otherwise wasted water at Aswan can be saved by implementing water conservation projects in the upper Nile sub-basin, through the cooperation of Egypt and the Nile basin countries. This excess amount of saved water would be used to fill the Toshka Depression completely—through

the Toshka Canal and the Toshka Spillway—turning it into a permanent storage reservoir that could be used as a stable water supply for irrigation.

A new canal would then be constructed to convey water from the depression northward towards the Cut-taara Depression through the western desert of Egypt, forming a new green valley parallel to the existing valley (Younan, 2001). This would create new communities aiming at expanding the Egyptian habitation land from the current 5% to about 25% of Egypt's area. Water would eventually be directed northward, as a second branch of the Nile and parallel to it, towards the Mediterranean Sea.

Started in 1998, the construction of the Toshka Project was hoped to be completed by 2004 with an estimated cost over US\$ 2.5 billion. The Egyptian government wants to reclaim and cultivate some 534,000 acres (890 sq miles) around Toshka to deal with Egypt's population explosion, crowded cities, and falling per-capita farm output.

The construction of the Toshka Project in Egypt presents a challenge to engineering technology because work is sometimes done under extremely unfavorable weather conditions. Production rates never before attained are becoming the norm in order to keep the sizable project on schedule.

The first fruits of the promising success of the Toshka Project can be witnessed in many locations such as that around Productive Well No. 21, at the 45 mile landmark, where the volume and density of the green color of vegetables, fruits, and flowers extend for almost 60 acres—wholly cultivated in an area previously thought of only as barren, uncultivable desert.

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Acknowledgement:

The author is indebted to a long list of colleagues, friends, and staff at Eastern Illinois University and elsewhere for their help, advice, and support of “Egypt 2001”—the EIU study abroad course. Special thanks are due “my friends”—Egypt 2001 participants—for their enthusiasm and interaction that made the course a memorable success. My deep appreciation goes to Dr. Mahyar Izadi, chair, School of Technology; Dr. Ted Ivarie, former dean; Dr. Martha Brown, acting dean, Lumpkin College for Business and Applied Sciences; and Dr. Bob Augustine, dean, Graduate Studies and International Programs, for their continual and unfailing support of Egypt 2001 since its inception. For valuable information and warm hospitality, a word of gratitude is due Egyptian officials, and our colleagues and friends in Egypt: The Honorable Dr. Yousif Waaly, Minister of Agriculture; The Honorable Eng. Ibrahim Khalil, Deputy Minister and Senior Under Secretary of Agriculture; Dr. Mamdooh Riyadd, director of the Central Office for Environment; His Excellency Eng. Mohammed Saddeek, mayor of Abu Simbel; Eng. Abdel Fat-Tah Hass-ssan, general manager of Toshka Project Research and Engineering Studies; Eng. Hussain Taha, manager of Toshka Project Quality Control; Eng. Mohammed Abdel-Rahman, general manager, Mubarak Pumping Station; Eng. Mohammed Khala-Fal-lah, director of Toshka Projects Follow-up; Eng. Saay-yed Abol-Hag-Gag, manager of Abu Simbel Station for Agricultural Engineering; Eng. Mohammed El-Hag-Gar, manager of Toshka Department of Plantation; Prof. Dr. Eng. Nazieh Younan, civil engineering consultant of Toshka Project; and Eng. Hatem Ramsis and Eng. Ekram Kadry of the Consultative Bureau for Civil Constructions.

Books Briefly Noted

Alexander, Brian (2003). *Rapture: A raucous tour of cloning, transhumanism, and the new era of immortality*. New York: Basic Books. ISBN 0-7382-0761-6, pb, \$15.00.

Brian Alexander takes readers into the surprising stories behind cloning, stem cells, miracle drugs, and genetic engineering to show how the battle for the human soul is playing out in the broader culture—and how the outcome will affect each and every one of us. *Rapture's* Dickensian cast of characters includes the father of regenerative medicine, an anti-aging guru, and a former fundamentalist Christian and founder of the company that reportedly cloned the first human cell. This motley crew is in part being united by the force of the opposition: a burgeoning coalition of conservative Republicans, the Christian right, and the Greens—predicting impending doom should we become adherents of the new bio-utopian faith. The book is irreverent, shocking, and highly entertaining as it seeks to separate hype from reality.

Anderson, John D., Jr. (2004). *Inventing flight: The Wright brothers and their predecessors*. Baltimore, MD: The Johns Hopkins University Press. ISBN 0-8018-6875-0, pb, \$18.95.

The invention of heavier-than-air flight craft counts among humankind's defining achievements. In this book, the renowned aeronautical engineer John D. Anderson, Jr., offers a concise and engaging account of the technical developments that help to explain the Wright brothers' successful first flight on December 17, 1903. While the accomplishments of the Wrights have become legendary, we do well to remember that they inherited knowledge of aerodynamics and considerable flying-machine technology. Beginning with the earliest attempts at flight, Anderson notes the many failed efforts. He tells the fascinating story of aviation pioneers such as Sir George Cayley who proposed the modern design of a fixed-wing craft with a fuselage and horizontal and vertical tail surfaces in 1799 and of William Samuel Henson who won a patent in 1842 but never flew. He also examines the crucial contributions of German engineer Otto Lilienthal to the science of aerodynamics. With vintage photographs and informative diagrams, *Inventing Flight* will interest anyone who has ever wondered what lies behind the miracle of flight.

Beattie, Andrew, Paul R. Ehrlich (2004). *Wild solutions: How biodiversity is money in the bank*. New Haven, CT: Yale University Press, 2nd edition. ISBN 0-300-10506-1, pb, \$16.00.

In this fascinating and abundantly illustrated book, two eminent ecologists explain how the millions of species on Earth not only help keep us alive but also hold possibilities for previously unimagined products, medicines, and even industries. In an afterword written especially for this edition, the authors consider the impact of two revolutions now taking place: the increasing rate at which we are discovering new species because of new technology available to us and the accelerating rate at which we are losing biological diversity. Also reviewed and summarized are many "new" wild solutions, such as innovative approaches to the discovery of pharmaceuticals, the "lotus effect," the ever-growing importance of bacteria, molecular biomimetics, ecological restoration, and robotics.

Bergeron, Kenneth D. (2004). *Tritium on ice: The dangerous new alliance of nuclear weapons and nuclear power*. Cambridge, MA: The MIT Press. ISBN 0-262-52433-3, pb, \$15.95.

This winner of the Gold Award in Political Science in 2002 is now in paperback. For more than 50 years after the start of the nuclear age, the U.S. followed a policy barring commercial nuclear reactors from producing the ingredients of nuclear weapons. But in the fall of 2003 all that changed when a power plant operated by TVA started making tritium for the Department of Energy at the same time producing electricity for the commercial grid. Tritium, a radioactive form of hydrogen, is needed to turn A-bombs into H-bombs, and the commercial nuclear power plant that was modified to produce tritium is of a type called "ice condenser." This book provides an insider's perspective on how this nuclear policy reversal came about, and why it is dangerous.

Bødker, Keld, Finn Kensing, Jesper Simonsen (2004). *Participatory IT design: Designing for business and workplace realities*. Cambridge, MA: MIT Press. ISBN 0262-02568-X, hc, \$50.00.

The goal of participatory IT design is to set sensible, general, and workable guidelines for the introduction of new information technology systems into an organization. Reflecting the latest systems-development research, this book encourages a business-oriented and socially sensitive approach that takes into consideration the specific organizational context as well as first-hand knowledge of users' work practices and allows all stakeholders—users, management, and staff—to participate in the process. Drawing on the work of a 10-

year research program in which the authors worked with Danish and American companies, the book offers a framework for carrying out IT design projects as well as case studies that stand as examples of the process.

Broadbent, Marianne, Ellen Kitzis (2004). *The new CIO leader: Setting the agenda and delivering results*. Boston: Harvard Business School Press. ISBN 1-59139-57-1, hc, \$35.00.

Two converging factors—the ubiquitous presence of technology in organizations and the recent technology downturn—have brought Chief Information Officers to a critical breaking point. Then can seize the moment to leverage their expertise into a larger and more strategic role than ever before or they can allow themselves to be relegated to the sideline function of “chief technology mechanic.” Drawing on extensive Gartner, Inc. interviews and research with thousands of CIOs and hundreds of companies, the authors outline the agenda CIOs need to integrate business and IT assets in a way that moves corporate strategy forward. Dozens of case examples appear throughout the book including AXA, Banknorth, British Airways, Citigroup, Commerce Bank, Disney, SKF, Starwood, Unicef, and U.S. city and federal agencies.

Bunch, B. & Hellermans, A. (2004). *The history of science and technology: A browser's guide to the great discoveries, inventions, and the people who made them from the dawn of time to today*. Boston: Houghton Mifflin. ISBN: 0-618-22123-9, \$40.00.

Have you ever wondered how bridges are built? Do you know what medical discoveries led to the introduction of vaccines and antibiotics? Do you know why PCR (polymerase chain reaction) is one of the pillars of the biotechnology revolution? *The History of Science and Technology* is the ultimate resource for answers to questions about the when, what, why, and how of science and technology.

This accessible reference work, organized within 10 major periods of history, is a comprehensive, chronological guide to the scientific discoveries and technological innovations from the earliest periods of recorded history into the 21st century.

With more than 7,000 concise entries in such fields as archaeology, biology, computers, food and agriculture, medicine and health, and transportation, the book covers trends, important breakthroughs, births, deaths, and other useful information. Features include:

- in-depth section introductions that place each epoch in context
- short essays on intriguing topics, such as the history of DNA, the transit of Venus, the nature of light, and the relationship between electricity and magnetism
- 300 brief biographies of such personalities in science and technology as Galileo, the first scientist of the scientific revolution, and Charles Babbage, designer of the first mechanical computer
- 300 black-and-white drawings and photographs

Most entries are cross-referenced so that the reader can easily trace connections over time. This arrangement allows the reader to choose between following the development of a specific field through history and focusing on the breadth of innovation during a certain period.

Browsable yet richly detailed, *The History of Science and Technology* is an invaluable desktop reference for general reader and educator alike.

Campbell-Kelly, Martin (2004). *From airline reservations to Sonic the hedgehog: A history of the software industry*. Cambridge, MA: The MIT Press. ISBN 0-262-53262-X, pb, \$16.95.

From its first glimmerings in the 1950s, the software industry has evolved to become the fourth largest industrial sector in the U.S. economy. Starting with a handful of software contractors who produced specialized programs for a few existing machines, the industry grew to include producers of corporate software packages and then makers of mass-market products and recreational software. This book tells the story of each of these types of firms, focusing on the products they developed, the business models they followed, and the markets they served.

Cassidy, David C. (2004). *J. Robert Oppenheimer and the American century*. New York: Pi Press. ISBN 0-13-147996-2, hc, \$27.95.

The story of J. Robert Oppenheimer, physicist extraordinaire and the man who led the scientific team for the Manhattan Project that built the atomic bomb, has fascinated many people. Award-winning author David Cassidy, using previously unexamined documents, presents for the first time an integrated and coherent account of the man within the context of the nation he loved and so profoundly affected. Cassidy has crafted a richly detailed, gripping, and nuanced look at the theorist who theorized about black holes, the humanist who read Sanskrit, the man who loved his family, and the statesman who confronted the hardest

moral dilemmas and scientific problems of his age. The hidden story of the political and social forces that shaped the world in the 20th century is the rise of American science, and Oppenheimer was at its epicenter. His story is at the crux of America's astonishing rise to power and an insight into the technological progress of our nation.

Chadarevian, Soraya de, Nick Hopwood, Eds. (2004). *Models: The third dimension of science*. Stanford, CA: Stanford University Press. ISBN 0-8047-3971-4, pb, \$24.95.

Now that "3-D models" are so often digital displays on flat screens, it is timely to look back at solid models that were once the third dimension of science. This book is about wooden ships and plastic molecules, wax bodies and a perspex economy, monuments in cork and mathematics in plaster, casts of diseases, habitat dioramas, and extinct monsters rebuilt in bricks and mortar. These remarkable artifacts were fixtures of laboratories and lecture halls, studios and workshops, dockyards and museums. Considering such objects together for the first time, this interdisciplinary volume demonstrates how, in research, as well as teaching, 3-D models played major roles in making knowledge. Accessible and original chapters by leading scholars highlight the special properties of models, explore the interplay between representation in two dimensions and three, and investigate the shift to modeling with computers. The book is fascinating reading for anyone interested in the sciences, medicine, and technology, and in collections and museums.

Clarke, David, Ed. (2005). *Theory of technology*. New Brunswick, NJ: Transaction Publishers. ISBN 0-7658-0844-7, pb, \$29.95.

The history of technology is often troubled by good ideas that do not, for one reason or another, take off right away—sometimes for millennia. Sometimes, technology comes to a standstill, and sometimes, it even reverses itself. Thus, unlike science, which seems to proceed at a reasonable and calm rate, the progress of technology is difficult to theorize about. David Clarke brings together 10 authors from a range of disciplines who try to understand technology from a variety of viewpoints. These essays originally appeared in two issues of *Knowledge, Technology & Policy* in 2002 and 2003.

Eglash, Ron, Jennifer L. Croissant, Giovanna Di Chiro, Rayvon Fouché, Eds. (2004). *Appropriate technology: Vernacular science and social power*. Minneapolis, MN: University of Minnesota Press. ISBN 0-8166-3427-0, pb, \$25.95.

From the vernacular engineering of Latino car design to environmental analysis among rural women, to the production of indigenous herbal cures—groups outside the centers of scientific power persistently defy the notion that they are merely passive recipients of technological products and scientific knowledge. This work is the first study of how such "outsiders" reinvent consumer products—often in ways that embody critique, resistance, or outright revolt.

Emsley, John (2004). *Vanity, vitality, and virility: The science behind the products you love to buy*. New York: Oxford University Press. ISBN 0-19-280509-6, hc, \$28.00.

Acclaimed popular science writer John Emsley explains the nature and behavior of about 40 ingredients that play important roles in every aspect of modern living. There are chapters on cosmetics, foods, sex, hygiene, depression, and on four unexpected ways in which modern products improve our lives. So if you have ever asked yourself whether cosmetics can deliver what they promise, whether certain spreads really can reduce cholesterol, whether nitrates in water are a cause of cancer, or whether Prozac is as safe as they say, dive into *Vanity, Vitality, and Virility* and discover things you always wanted to know.

