Table of Contents

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and persuasion, ability to lead and work effectively as part of a team, an understanding of non-technical forces that profoundly affect engineering decisions, and a commitment to life-long learning.

For a variety of reasons the Accrediting Board for Engineering and Technology (ABET) changed the accrediting procedures for engineering programs. The new criteria (see Table 1) place strong emphasis on defining program objectives consistent with the mission of the institution and learning outcomes, i.e., the intellectual skills of the graduates. (Prados, 2005) A few years ago Douglas Gorham (Gorham, 2003) compared the new ABET criteria with the Standards for Technological Literacy and found that the standards matched very well to them. This may be due to the influence that a group of engineers appointed by the National Academy of Engineering to review the Standards had on them. However, a review of the fourteen ABET criteria also demonstrates that engineering is a way of thinking. From what we know about engaging women and minorities in learning, the broader goals are helpful. Women particularly respond to learning in meaningful contexts. It is still true that women are underrepresented in engineering schools, but there are reports that at earlier grades there is no gap between learning of boys and girls in technology education classes.

Table 1: ABET Criteria

The Accrediting Board for Engineering and Technology (ABET) criteria include abilities to:

- apply the knowledge of mathematics, science, and engineering;
- design and conduct experiments as well as analyze and interpret data;
- design a system, component, or process to meet desired needs;
- function on multidisciplinary teams;
- identify, formulate, and solve engineering problems;
- understand professional and ethical responsibility;
- communicate effectively;
- understand impact of engineering solutions in global and societal contexts;
- engage in life long learning;
- be aware of contemporary issues;
- use the techniques, skills, and modern engineering tools necessary for engineering practice; and
- manage a project.

The criteria demonstrate that engineers must be broadly educated and that linking with engineering does not narrow the choices for technology education but broadens them. The liaison strengthens technology education because now it would be connected to a discipline that has stature in both the academic and business communities. Engineering provides an intellectual base for technology education. However, the base is not without cost, since one of the major differences between technology and engineering is the use of analysis - scientific and mathematical. When ninth grade science courses become too mathematical, students complain. This may cause major issues in technology courses; but it should not. The complaint may be because students have not learned the mathematics by methods so that they can apply it in new situations. Very little attention is paid to the question of what mathematics is needed in this problem. With the emphases in Career and Technical Education on increased competency in science and mathematics, the move toward engineering in technology education also provides opportunity to gain support from this community.

One of my two major responsibilities at NSF is the Advanced Technological Education Program - technician education - not training - at the two-year college level and preparation for that in the secondary schools. The goal of the program is to increase the quality and quantity of technicians for the high performance workplace. The object is to develop technicians who have adaptive expertise. Technology education should provide the base. In fact the teacher education part of the ATE program explicitly mentions the education of technology educators. In the interest of full disclosure the most direct four-year degree route for students in this program - if that is what they want to do - is to engineering technology. So a well engineered K-12 program in technology education can lead to engineering technology education as well.

The technology education profession has worked hard on the issue of the content of its discipline and on how to be educated to teach it (ITEA, 2000); but perhaps needs to think more strategically about other dimensions like where can it get support? The present situation in schools is constrained by the accountability movement. The high stakes tests seem to drive administrators and teachers to uneducational behavior, despite the results from cognitive and learning scientists as summarized in some excellent studies by committees of the National Academies (Bransford, 1999; Pellegrino, 2001; NRC, 2002, Donovan, 2005). Some of these studies agree that authentic contexts help students learn in ways so that they can transfer the knowledge to new situations. The context helps to provide a scaffold that makes the knowledge accessible when it is useful in other situations.

Technology educators can increase the opportunities for students to become more technologically literate by collaborating with teachers in other disciplines. What is to be learned in technology or engineering laboratories has been studied by engineering educators (Feisel, 2005). They too have a long list of objectives. The NRC (NRC, 2005) is studying learning in high school science laboratories. The issues are much the same. I have conjectured that although the respective goals are inquiry and design, the methodologies are very similar (Salinger, 2003).

Working with science educators is the greatest lever for increasing instruction for technological literacy in schools. Design and technology are part of the science standards (AAAS, 1993; NRC, 1996). Applications are tolerated in the mathematics standards (NCTM, 2000). The Program for International Student Assessment (PISA) measures 15 year olds' capability in reading, mathematics and science literacy by examining one of the areas in depth every three years. The examination focuses on the ability of students to apply knowledge. As you might expect, US students did not do well in the emphasis on problem solving in mathematics in 2003 (Bybee, 2005). Yet it measures an important strength. The examination for National Assessment of Educational Progress (NAEP) is being revised and the ideas of design and technology as related to science are being discussed. Thus there is a national push for understanding design.

We are seeing more and more cooperation between developers of science instructional materials and technology educators. I would mention the development of Active Chemistry and the revision of Active Physics (http://www.its-about-time.com/htmls/ap.html) as examples; the Materials World Modules (www.materialsworldmodules.org) are another example. In each, the design of something is the assessment that the content is learned and attention is paid to the issue of design (See also the theme issue of the *Journal of Industrial Teacher Education, Vol. 39*(3), 2002). I have had conversations with a leading science educator (Krajcik, 2005) who uses as the example of an inquiry question: Can I drink the water in Honey Creek? I suggested that the question could also be: What do I have to do to the water in Honey Creek so that I can drink it? He is very intrigued. The science is the same, but my question asks for action. (Notice that there are several answers depending upon the pollutant; but also one can do something to the water at hand or one can also investigate the source of the pollution.)

As the funding for the Directorate for Education and Human Resources at NSF is being redirected, we are discussing possible new directions. We are asking how science and technology education would look if there were coherent learning progressions of content and process throughout the educational experience. For the first year, we are limiting the progressions to modeling, engineering design and inquiry in the context of content emphasized in

Table 2: Goals of Engineering Laboratory Experiences

Students should be able to:
• apply appropriate instrumentation including software tools to make measurements; • identify strengths and limitations of theoretical models; • devise an experimental approach, specifying and implementing equipment and procedures to take and interpret data to characterize engineering materials, components, or systems; • analyze and interpret data; • design, build, or assemble a part, a product, or a system; • identify and learn from unsuccessful outcomes; • demonstrate levels of independent thought, creativity, and capability in solving real world problems; and • understand impact of engineering solutions in global and societal contexts; • select, modify, and operate appropriate engineering tools.

Table 3: Laboratory Goals

Students should be able to:
• identify and deal with health, safety, and environmental issues related to technological processes; • communicate effectively about the laboratory experience in writing and orally; • work effectively in teams; • behave with highest ethical standards; and • use the human senses to gather information and to make sound judgments in formulating conclusions about real-world problems.

the standards. If the goal were to have students reach a competency with the use of design by the time they leave high school, how would instruction look in grades 2, 4, 6, 8, and 10? How are teachers successfully educated - both preservice and inservice - to deliver this kind of education?

At the elementary school, the emphasis is on reading and mathematics. I recently met with a group of people who have had success in increasing the literacy of students with science materials. They had worked on the literacy, but the science was "read about." In the discussion, I brought up the possibility of using design problems. They became enormously excited, because they had already experienced success with these kinds of problems. It then occurred to me that students are frustrated if they cannot know something because they cannot read it. But think of how annoyed they are when they cannot do something because they cannot read it. Being able to do is far more motivating. The question is can we improve reading scores through technological experiences and still be true to the technology? We had rejected an earlier proposal from this group, because the doing of science had been neglected.

Another area is after school programs. Learning through the ideas of design provides a context to learn that is very different from that in schools. The same subject matter may look very different and the students learn about design at the same time. This can be simultaneously coupled to improving reading ability. In the world of informal education, there are many opportunities for technological exhibits that provide insights into engineering experiences.

The publication of the National Academy of Engineering, Technically Speaking, provides many other excellent suggestions (Pearson, 2002). I look forward to seeing the increase in emphasis on both scientific and technological literacy with science and technology educators working together.

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The Ingenuity Imperative

John W. Hansen

This paper is based on a Keynote Address given at the Texas Technology Education Professional Development Conference July 24 -27, 2005 in Corpus Christi, Texas.

When I looked carefully at the attendance list for this conference, I realized that a number of you have been at this conference every year, for the past ten years, as I have. For the last decade I have had the pleasure of working with many of you as we attempted to create a better, technologically-savvy Texan. But I think few of us really understood the future importance of our work as rapidly evolving technologies created an increasingly complex tomorrow. The future really is the result of the choices we make today. What we decide and do, today, actually matters to history and will determine the landscape for decades and centuries to come. I have something important to share with you today about the future of technology education in Texas.

Ten years doesn't seem like a long time, but let's quickly look at what has developed since 1995:

Cell phones
Wireless internet
Hybrid cars
PDAs
MP3 players
The Genome Project
Viagra
Lipitor
Stem Cell Research
Nanotechnology
Genomics, proteomics, bioinformatics
The presence of water was discovered on the moon
The presence of life on Mars
DVDs
The Hubble space telescope
Smart weaponry
The Boeing 777 was designed
Pixar created the first computer generated full length feature film “Toy Story”
Intel released the 200 MHz Pentium processor
Internet fraud and viruses
Biological imaging

Did you prepare any of your students for these changes and new technologies?

Our world has changed more in the last 100 years than in all the preceding years of humanity. We are healthier, safer, and more productive. We live in a world dominated by a single species' technology and not nature. We have longer, healthier lives, improved work and living conditions, global communications and travel, and unparalleled access to art and culture. This is true for most of us in the developed world, not just a privileged few. Of course, most of the people of the world do not benefit from these advantages and it will be the challenge of future generations to spread the positive aspects of our innovations throughout the world.

We all want to know the future; we try to predict what the world will be like.

As educators, we try to prepare students for a world that is unknown. To be frank, we provide to the students knowledge, skills, and dispositions that were valuable during our time, decades ago. I ask you, is this strategy in our best interest, to prepare kids for our past? Or should we try to envision our students' world and revise our curriculum to prepare them for this future?

What do you think the future, 2020 will look like?

Let me show you one of my favorite movie clips from the original H.G. Wells movie, The Time Machine. This scene captures the essence of what I am talking about.

Hold on to the following thought, “Which three books would you take into the future to build a new civilization?” What enduring knowledge would you carry into the future to build a new world? Is it what you are currently teaching in your class? I hope you capture the importance of what I am saying. Our world will be dramatically different in the next decade. How are we preparing the kids of today for the decisions of tomorrow?

What will the future look like? What do you think the next decade will bring? Let me share a few things we know are on the horizon.

The future will be filled with exciting breakthroughs in human physiology. Working at the cell level, diseases that we know today will be eradicated. The effects of aging can be reduced. Tissue engineering and regenerative medicine may lead to new technologies that will allow our bodies to replace injured or diseased parts without invasive surgery. Rather than the barbaric equivalent of running a sewer snake through our arteries, nanobots will clean our clogged and blocked arteries. Drugs will be customized for each individual. Embedded devices will aid in communication and monitoring our organ functions.

Nanoengineering will create and manufacture structures at the molecular, even atomic level. Environmental cleaning agents, chemical detections agents, the creation of biological organs, nano electronic systems, and ultra fast, ultra dense electrical and optical circuits will result from nanoengineering.

Our perceptions of connectedness, location, and access will change as the world becomes more connected electronically. Everything will become smart. Every product, service and system will be directed at meeting the needs of the humans it serves and will adapt its behavior to those needs.

In 2019 a $1,000 computer will have the computing capacity of the human brain. In 2029 the same computer will have the computing capacity of 1,000 human brains. In 2039 the computer will claim to be conscious and self-aware. These claims will be largely accepted.

We will struggle with those who attempt to use new chemical and biological discoveries as weapons. We will need a better understanding of the transport characteristics of biological and chemical agents.

The United States has probably the best physical infrastructure in the developed world. But these systems are degrading rapidly. Our water treatment, waste disposal, transportation, and energy systems are in serious need of replacement and redesign.

As we depend more on the information infrastructure it becomes more vulnerable to accidental, terrorist, and malicious attacks. This will impact our national economy, national security, our lifestyles, and our sense of personal security. At the same time issues of privacy and access have to be addressed.

In the next 20 years, every nation in the world will face some type of water supply problem. Currently, 2 billion people live in conditions of water scarcity. Water supplies will affect the world's economy and stability.

Ecological sustainability must be a consideration as we develop new technological solutions to the problems we create if we are to have economic prosperity. Green engineering, the design, commercialization, and use of processes and products must become mandatory if we are to mitigate the risks to human health and the environment that we have created.

What we know about science and technology today will double in 10 years. It will become increasingly difficult for us to understand the total body of knowledge of a field. The notion that a person learns everything he or she needs to know for a life-time in a four-year degree is not true. It really never was. You and your students will need to accept the responsibility for re-educating yourself.

When engineers begin sketching a design they do it not only with a foundation in the sciences, they also use the tacit knowledge gained from their experiences. Tacit knowledge is grounded in objectivity. It is the knowledge that is gained by doing, not imagining. Tacit knowledge and experience prevent us from wasting energy on fanciful ideas that violate known scientific principles. Western society values its deep scientific understandings. In fact, we judge our national prowess by the strength of our scientific discoveries and the rate at which we accumulate knowledge. We also value the discoveries of the humanities, whether by poets, painters, writers, or dancers. In fact, we consider these successes to represent the height of human endeavor. But, for a variety of reasons, we don't value the contributions of the ingenious, the innovators, nor the inventors. While their work is not in the direct pursuit of

> Civilization, as we know it today, owes it existence to the engineers. These are the men who, down the long centuries, have learned to exploit the properties of matter and the sources of power for the benefit of mankind. By an organized, rational effort to use the material world around them, engineers devised the myriad comforts and conveniences that mark the difference between our lives and those of our forefathers thousands of years ago.

The ingenious, the innovative, the inventive are driven by a deep passion to conceive new technology, to build it, and to make it work. Innovations and inventions occur when a need arises or an opportunity presents itself. Science rarely translates into technology directly. Many advances of technology occurred before we knew about the science. But this is a model that is now no longer valid. Human-made artifacts are now principally designed through rules, principles, and predictions rather than trial and error. Today we find that the work of scientists and engineers are growing closer together and are sometimes indistinguishable. The thrill of the scientific discovery and the engineered creation are intellectually challenging and satisfying.

The goal of science is to discover the laws of nature and understand its behavior. The goal of engineering is to create technology that meets the needs and wants of humanity. "Science deals with what is, comprehending nature as it exists; engineering focuses on the future. It creates new material environments, producing products, processes and systems that did not previously exist." (Lewis, 2004)

I see three overwhelming threats to our American way of life that I believe, we as technology and pre-engineering educators can address through a single strategy: Ingenuity Education.

The first threat is related to human and technological growth. The world population is, as we know, increasing and the problems created because of this growth are complex. Energy themselves, create unanticipated problems which are often more complex than the original problems. So, we have technological growth problems and population growth problems.

Problems require human ingenuity, innovation, and inventive solutions if they are to be sustainable. There is a possibility that we may be approaching an "Ingenuity Gap." As population and technological growth increases, new complex problems are created and there may be a point at which we will not have the inventive, innovative or ingenuity capabilities for solving them.

This is an interesting concept for us to grapple with because we've always believed in "Yankee Ingenuity" and how we would always solve whatever problems were encountered. Looking around the world, we already see many countries where the creative workforce capabilities are not sufficient to solve its current problems. The only solution for these countries is to import the intellectual capabilities.

The "Ingenuity Gap" theory, developed by Thomas Homer-Dixon is an alarming conceptualization and potential call to arms for education. We've always been able, as a nation, to develop more solutions than problems. A significant part of the American high quality of life is related to innovation and ingenuity. But, we may be approaching a point, somewhere around year 2020, when we might we are unable to solve our present problems. That is, when our present intellectual capabilities are insufficient for solving the new problems. We would have an "Ingenuity Gap." The "Ingenuity Gap" is a critical theory that we must consider now if we are to "head off" its devastating consequences.

The second threat is a new division of labor. Many current jobs are being replaced by automated machines and low-cost labor. We teach about the effects of automation in our robotics classes. The secondary and postsecondary education system was unprepared for the rapid changes in the labor force as a result of the application of information and computer technology. Many of the jobs we are preparing students for are no longer available. If they are, they are low-paying non-family supporting jobs. Information and computer technology have dramatically impacted the way in which we work. Electronic communication technologies have allowed many jobs to be completed in distant, offshore locations. When you call a company for their 24/7 service, it is not that a single location is staffed 24 hours a day. It may be that, in different time zones around the world, there's another shift worker processing your request. I think we are ignoring the profound effects this will have on sustaining a high quality American lifestyle.

Outsourcing. What's your the number one complaint when you go through a fast-food restaurant drive-through? You get the wrong order or you're missing something! You've learned to open the bag and check to make sure you got all your fries and burgers. Did you know in St. Paul, Minnesota that a national fast food restaurant is experimenting with outsourcing the order taking process? When you drive up to the window, to the little box where you speak your order, that the person talking to you is not located in that building – he/she is in North Dakota. You give your order to the person in North Dakota who then transmits it to the food preparers in the building. Why, you might ask: in order to increase reliability and give greater customer satisfaction. It probably won't be too much longer before they find it can be done in some place cheaper than North Dakota.

I think we are experiencing a massive redistribution of labor and probably a redefining of the American way of life that we need to pay attention to. This new division of labor is going to be based on two concepts. One is rule-based, procedure-based jobs that don't require creative solutions, are easily programmed, easily outsourced and easily automated. All that is required is to follow the procedures, follow the flowchart. Notice that when you call technical support for you new appliance that they ask you a series of questions. Once they get to the end of their script, so to speak, they'll transfer you to the next level of technical support, to somebody with new script of questions. Its mass production type work with limited thinking and absolutely no creativity required.

The second division of labor will be the creativity, innovation, imagination and ingenuity-based jobs. These are high-value, economy building jobs. They are high wage jobs that support a high quality of life. The economic function of creative talent is to generate new ideas, technologies, and solutions. I think there is an impending creativity crisis that will lead to a national "Ingenuity Imperative." We really need to look at the issues before us. Creativity-based jobs include scientists, engineers, architects, designers, educators, artists, musicians, technologists, leaders, managers, business people, finance people, lawyers, healthcare professionals, communication specialists, and the entertainment sector. These are the people that use their minds to develop new solutions to current, new, and recurring problems. We should be alarmed at the shrinkage in the American creative talent pool.

The third threat – security and safety – is one which I heard from Congressman Vernon J. Ehlers, and I think it is very important for us to consider. The issue is homeland security. He stated very simply, "Those we educate today will protect us tomorrow." The military requires an increasingly sophisticated soldier. Counterterrorism will require more advanced capabilities if it is to win the war on terrorism. The destructive radical innovator/inventor must be minimized. What are we doing to foster the intellectual capabilities of our youngsters to protect their futures?

What are we to do? The American creative talent pool that feeds the high tech, high margin industries is, in fact, shrinking. New talent, if we're looking at it from that perspective, is not sufficient for the future demands. Innovation education is, tragically, not a part of the American public education system. I had the opportunity to talk with several technology educators from New Zealand who indicated New Zealand had made innovation education a part of its national economic development plan. It's a part of New Zealand's strategy for survival, sustainability, and economic growth.

Let me suggest two solutions for your consideration. First, we need better technological planning and decisions based on technological literacy. Reconsidering the "Ingenuity Gap, we may be creating more problems than we can solve and the adoption of some of the technologies that we create should be reconsidered or even halted. This requires an informed decision maker and the current education system does not provide opportunities for students to become technologically literate. The citizens of the choose to develop or use a plethora of new technologies.

Second, we should also think of creating better technology through increased ingenuity, innovations and inventions. Good decisions about technology I think are important, but it is not enough. Engineers and technologists are those prepared to imagine, design and build a better world. We and our societies change with the diffusion of technology. We don't understand what's happening and we don't even see what's happening until it actually happens. So, we need to understand the place and role of existing and new technologies in their social organizations as well as their future impacts on society as a whole.

I developed the concept Five Pillars of Technological Literacy, which I believe support sustainable technological and economic advancement. These are characteristics that I would like to see evidenced by all kids: (1) I want a kid who walks into a situation and says, "I can solve this. I'm not afraid of this technology." We refer to this as technological self-efficacy. That's the kind of kid I want working for me or preparing for my future. (2) I want kids that can say, "I've made a good decision." They have a rational decision-making process. They've actually thought about not only the process but the decisions they've made. (3) I want kids that say, "You know, I understand the issues of technology. You know, I do understand the science also, and I do understand the social impacts that are related to this." I refer to this as pre-requisite knowledge and skills. (4) I want kids that can say, "This is a good application. We chose the right technology for this problem." So, there's critical application. (5) And certainly we want kids who are able to say, "Let me rethink this. Let me make sure that the solution that I created, that I adopted or adapted or invented is the right one." They reflect on why they did what they did in order to make sure that it was a good decision, and to try and improve their own thinking processes. The Five Pillars of Technological Literacy are dispositions which are important for us to foster in our students. Technological literacy supports these characteristics.

ing. Second, one can adopt what others have done. One does a search of how others have solved the problem. This is a part of our problem-solving methodology. Third, one can adapt a solution. One looks at what others have done and says, "That doesn't quite fit; let's tweak it; let's modify it; let's be innovative; let's change it just a little bit and it will meet our needs." The fourth option is to invent a new solution. The ability to adopt, adapt, invent and evaluate technology to positively influence the community and the environment is what technological decision-making encompasses. The ability to consider these decisions options is a fundamental part of a technologically literate society.

The ingenuity component of my solution is something new. As you know, there's tremendous effort – millions and possibly billions of dollars are spent for science and mathematics education. We need new solutions and better solutions, and increased math and science capabilities are important. But, I ask you, if we have already spent millions and billions of dollars in trying to increase math and science education as a solution to this problem, why are we in a creativity crisis? Why are we in a situation where America is no longer the world's innovation powerhouse? I believe we find ourselves in this situation because mathematics and science education are directionless. Without coupling these capabilities to the creative abilities of our students we will continue to lose dominance as an innovation nation. Ignoring the ability to be innovative, ingenious and inventive is a tragic and potentially catastrophic mistake of our public education policy. Science and mathematics education is only one aspect of this sustainable economic future. Innovation, ingenuity, and inventiveness must be a part of every child's education. It is something we can contribute to as technology educators.

I think we are at a critical moment in American economic history. A tremendous amount of money is being spent once again for mathematics and science education, which is critical to the development of new technologies. The old trial and error method that we used (what I affectionately refer to as successive approximation which sounds much better than trial and error), has left us with a creativity crisis. We have no nationwide plan for K-16 innovation, ingenuity and invention education. I think we need to act now on this issue. We as informed and concerned technologists and pre-engineering educators must embrace this opportunity to build a better world.

An interesting book *The Engineer of 2020 – Visions of Engineering in the New Century*, released by the National Academy of Engineering (2004), confirms my supposition on these items. The NAE wanted to see how they could foster change in engineering education and suggested several attributes of a 2020 engineer. Look at the first three attributes they identified – (1) strong analytical skills, (2) practical ingenuity, and (3) creativity (i.e., innovation, invention, thinking outside the box and art.) How's that! Gee whiz, isn't that something that we do in our laboratories and classrooms? We teach kids how to plan, how to combine, how to adapt things to solve problems. These are the attributes the NAE thinks are important for engineers in 2020. I think these attributes are important for every citizen in the United States.

This is Technology Education's decade. This is the decade when we will make a difference in public education, and I wonder, will we seize the problem and solve it by what we know, by even using our own innovation and ingenuity? Will we, instead, protect our past, or will we do nothing? This is our decade to lead the nation to a better tomorrow. So, I ask you to join us in unleashing your own ingenuity, your own innovative and inventive capabilities as you instruct future generations for a better world.

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Speculations on the Insights and Perceptions of Professor William E. Warner Regarding the Status of Technology Education and Its Future

James J. Buffer, Jr.

> We trained hard, but it seemed every time we were beginning to form up into teams we would be reorganized. I was to learn later in life that we tend to meet any new situation by reorganizing; and what a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency, and demoralization. (Petronius Arbiter, ca 60 A.D.)

Prologue, Warner the Scholar!

I feel honored to make this presentation on the 75th anniversary of the founding of Epsilon Pi Tau (EPT). My own initiation was conducted in Chicago at Chi Chapter in 1957. There are persons in this room who knew Dr. Warner very well, including my good friend and colleague, Professor Donald G. Lux, who recommended that I give this presentation. Lux was one of Warner's doctoral advisees, a good friend and professional colleague of his at Ohio State, and is an excellent Warner advocate and analyst. Don learned his leadership skills from Warner including delegation, and that is why I am here today. Thank you Don and rest assured that I will do my best to represent Professor Warner with dignity and distinction.

As I pondered how to begin my presentation on this momentous occasion, I reflected on the historical work and scholarly contributions of Professor William E. Warner. Without a doubt, the man was an intellectual genius whose personal and professional energies were devoted to the development and cultivation of industrial arts education.

Warner's Professional Mission

Warner was a tall, distinguished looking man who was always impeccably dressed and whose demeanor attracted the attention and respect of others. I recall an incident at Ohio University when Dr. Warner walked into a meeting during another professor's presentation and the speaker stopped talking. And, all eyes seemed to be on Warner as he strolled quietly down the aisle, and after taking a seat in the front row, instructed the speaker that he could now proceed.

Clearly, Warner was a man who "walked the walk and talked the talk," so to speak. He taught by example as indicated by his involvement of graduate students when undertaking creative and scholarly projects. Many of his master and doctoral students worked collaboratively to create historically monumental documents including "A Curriculum to Reflect Technology," "Plans for the Exemplary 'Laboratories of Industries,'" and "The Three Degrees—Assumptions and Patterns," which were guidelines for the development of baccalaureate, master, and doctoral programs in industrial arts education. Nothing was left to chance with Dr. Warner.

In addition, Warner is acknowledged as *the* person who promoted the creation of the American Industrial Arts Association and Epsilon Pi Tau. Both initiatives were important to elevate the level of professional and scholarly recognition of industrial arts education as a curriculum specialty and to support the professional integrity of industrial arts educators.

To gain such acceptance, he worked diligently negotiating with the leadership of the U.S. Office of Education and the National Education Association, particularly with the president and past presidents of its Art Division. As previously said, nothing was left to chance. He was a master at "networking," and I'll address this process and its political implications as we get into the heart of this presentation.

The EPT Challenge

Jerry Striechler challenged me to "get into Warner's head" and speculate how Warner, who contributed so much to the conceptualization of technology education, would view the profession's recent accomplishments and what the future holds for it. To expand on my analysis, I solicited feedback from two groups: one comprised of associates who worked or studied with Dr. Warner and the second composed of teacher educators or leaders who were aware of Warner's work and have leadership responsibilities in technology education today including participation in ITEA, EPT, CTTE, AERA, or related organizations.

Respondents were asked to be frank and were assured that no one would be identified to ensure anonymity. My role was to provide a composite analysis and synthesis of their responses. I also reflected at length on my knowledge of Warner and built that into my analysis. As part of this process, I reviewed a historical collection of Dr. Warner's personal correspondence given to me by Mrs. Ellen Warner after her husband's death, watched a video interview of Warner conducted by Dr. David Mohan, and read numerous publications written by or about W. E. Warner including Latimer's doctoral dissertation on Warner completed at North Carolina State University in 1972 under the direction of Delmar Olson, another one of Warner's doctoral advisees.

Questionnaire—Review and Analysis

A formal questionnaire was developed to collect the data and anecdotal information from the two groups identified. Copies were distributed to respondents via mail or e-mail, and upon 100% return, their responses were then compiled to be shared with the profession. Respondents were asked to place themselves in the "mind" of Dr. William E. Warner and critically review each of the statements that relate to the current status and future of technology education. Using a scale of 1 = not satisfactory progress or status, 3 = average progress or status, and 5 = outstanding progress or status, respondents selected the value that best described their perceptions (see Table 1). Respondents could also include a written response to "qualify" or expand on their perceptions, speculating on what Dr. Warner would probably say. And yes, I realized that this task would be quite a challenge because Warner was and remains an enigma today!

Table 1: Results of Questionnaire

GROUP I: PROGRAM STATUS AND VITALITY (2.40 Near Average)	
ITEM 1. Current status of *technology education* in 2004 based on the number of active programs and student enrollment in:	
a. Middle and secondary schools.	2.35
b. Accredited teacher education programs at the baccalaureate level.	1.69
c. Master's degree programs designed to enhance professional practice and development.	2.69
d. Doctoral programs to ensure and sustain teacher education/leadership pool.	2.50
ITEM 3. Recognition of technology education as a subject area valued as part of general education for all learners.	2.23
ITEM 5. The vitality of technology education as a subject area in K–14 and its mission to enhance the general education goals and objectives for all learners.	2.54
ITEM 10. The status and prominence of international technology education K–12 programs and collegiate programs that focus on technology teacher preparation.	2.80

GROUP II: CURRICULUM AND INSTRUCTION (2.97 Average)	
ITEM 2. Curriculum, terminology, and instructional activities inherent in middle and secondary schools that have evolved from what was known as industrial arts education.	3.15
ITEM 6. Implementation of the ITEA *Standards for Technological Literacy* in the United States.	3.08
ITEM 7. The extent to which current curricula, instructional programs, and activities are reflective of technology.	2.69

GROUP III: TRANSISTIONS TO ENGINEERING TECHNOLOGY (2.87 Average)	
ITEM 8. Appropriateness of instructional practices that link engineering and information technology activities compared to past efforts that focused on problem solving and activity-based learning and skills with tools, materials, and processes.	3.31
ITEM 9. The evolution of collegiate level industrial or engineering technology and human resource development programs and resulting demise of institutions and programs that focus on technology education teacher preparation and teacher education.	2.42

GROUP IV: LEADERSHIP AND DEVELOPMENT (3.41 Average +)	
ITEM 4. Leadership activities that help to improve the status and vitality of technology education across the K–12 curriculum and Higher Education.	3.31
ITEM 11. The mission, goals, and outcomes of professional organizations Warner helped to establish (ITEA & EPT); and their influence on enhancing the status, vitality, and growth of technology education programs (K–12 and Higher Education).	3.50

GROUP V: OTHER OBSERVATIONS	
ITEM 12. Please provide comments regarding other issues, topics, or concerns that you feel Professor Warner would offer on the 75th anniversary of the founding of EPT. For example:	
a. How would Warner, who contributed so much to the conceptualization of technology education, view the profession's accomplishments? b. What would Warner have to say about what the future holds for the profession? c. How would technology education be different if William E. Warner had not existed? d. How would technology education be different if Warner and most of his opponents had worked together to improve the program and its goals?	

Note: Questionnaire used scale of 1 = not satisfactory progress or status, 3 = average progress or status, and 5 = outstanding progress or status.

To help quantify and analyze the results, I combined the 12 statements into five groups. A brief synthesis of the results for each group follows. Those seeking a more comprehensive analysis and discussion of the study along with copies of the instruments may request them by contacting the author at bufferj@vt.edu.

Group I: Program Status and Vitality

The general consensus was that Warner would *not* be pleased with the current status or vitality of technology education programs, primarily because of the dramatic reduction of programs (K–12, teacher preparation, and teacher education) over the past three decades. He might even be "confused" if he made some site visits to various technology education programs across the country. He would see programs that are familiar to him (e.g., hands-on problem solving using a variety of tools, materials, and equipment). But, he would also see many programs made up of nothing but computers and/or a few technical modules and might wonder what was going on.

Furthermore, he would not be pleased to learn that:

1. Many teacher education programs have been replaced with majors in human resource development, training & development, and management or engineering technology.
2. Master degrees are no longer required for licensure or certification and many practicing teachers are now selecting other specializations for graduate study as security for alternative career placement.
3. The number of doctoral programs in technology education has declined dramatically, and the future professorial pool has dwindled. In 2003 about a dozen doctoral graduates matriculated in technology education, and career opportunities in higher education appear to be minimal.

On the bright side, there are approximately 40 technology education programs nationwide that are accredited through ITEA/CTTE/NCATE guidelines. This is a fairly constant number and, hopefully, in the future this number will increase.

Also, given Warner's involvement in international education, he would be pleased with the international activities of technology educators across the globe as evidenced by collaborative curricular efforts in Japan, the Netherlands, Taiwan, Australia, New Zealand, England, Finland, South Korea, and Hong Kong.

Group II: Curriculum and Instruction

The ITEA standards have clearly influenced the evolution of curriculum, terminology, and instructional activities from industrial arts to technology education. Many states and localities have upgraded their content for these programs based on the *Standards for Technological Literacy*. Hopefully, the instructional programs will focus on what we do best, namely, "hands on teaching and learning" about how industrial technologies shape our human-made world. And, we need to impress upon our state and national leaders that the study of technology (not narrowly defined as computers) is essential to the health of our nation.

Associates felt that Warner might approve of the "technological problem-solving method" that has been transforming our practice in the past two decades and that he would understand the need to include new technological tools and processes. Tools have changed and are increasingly digital, which appear to be appropriate for a curriculum designed to reflect technology. However, Warner might find this explanation too simplistic. One must also consider the variety of "tools" and processes that humans use to change the form of materials to meet their consumer needs. For example, one cannot troubleshoot and replace a thermostat on a water heater or install a grab bar in a shower solely by studying computer programming.

Warner would not be concerned that the new programs are not consistent with the mission and goals he professed as part of the *Prospectus* and *Curriculum to Reflect Technology*. Rather, he would be more concerned about the assertion that the name *technology education* has little or no identity today. Furthermore, he would say that there is not much uniqueness to the field anymore to a point that almost any teacher could teach technology education without a laboratory.

Group III: Transitions to Engineering Technology

As mentioned earlier, vital signs are bad primarily because we are not producing enough teachers and we are closing too many teacher education programs. Warner would be very disappointed with the almost nationwide abandonment of teacher education in favor of industrial technology, engineering technology, or human resource programs that have been built on an industrial arts platform and that then have allowed the teacher education programs to dwindle and die.

A few respondents expressed positive outcomes coming from formal collaboration with engineering departments, especially in the delivery of preservice preparation of technology education teachers. And from my perspective, this can become a mutually beneficial outcome for both disciplines, engineering and education alike.

While Warner would embrace some of the new innovations as being important to keep up with our technological and cultural shifts in society, he would also remind us that we ought not leave behind what we have so long known and practiced about activity and activity learning, especially as one begins to link with engineering and information technology. One cannot forget his many pronouncements of teaching the value of "doers versus talkers" and his recommendation that general studies in technology education should continue to focus on our "industrial" heritage within the social-cultural context.

Results of the earlier Gallup poll sponsored by the Standards Project support the "integration" of technology with other subjects in the schools. However, one must be cautious when considering the significance of those results because respondents did *not* know what *technology education* really was. Most thought it had something to do with computer instruction or instructional technology. I am aware that the Standards Project's leadership staff has taken steps to resolve this issue as part of their recent project updates.

Group IV: Leadership and Development

The creation of EPT and ITEA was clearly a stroke of genius and was due almost solely to the work and commitment of William E. Warner. Clearly, both organizations have done much good for providing professional and scholarly recognition to technology educators and the profession.

National leaders report that EPT and ITEA have remained supportive of each other while each has moved forward with the times. Both have had to deal with globalization for example and have adapted well to this influence. For the most part, respondents felt that EPT and ITEA have stimulated and contributed to major change in our profession over the past few years. A few persons did comment that Warner's heart and soul were devoted to teacher education, and questioned EPT's decision to extend its membership and services to nonteaching "industrial technology" fields.

Our profession has created and maintained relationships with accreditation groups such as NCATE, placing our field in the position of having superior accreditation standards along with the other core subjects in our schools. The Standards' initiatives were also a great addition. However, teachers struggle knowing how to make good use of them as far as the curriculum is concerned. ITEA has responded with a written innovative, standards-based technology education curriculum. Through their Bright Ideas and ICON (Innovative Curriculum Online Network) there is a "central source for information dealing with technology and innovation about the human built and innovated world" and it is correlated to the Standards of Technological Literacy. These appear to be excellent curriculum initiatives and their adoption/adaptation by the profession will be indicators of their long-term value in restructuring the technology education curriculum. ITEA is to be congratulated for involving local and state educational agencies, teachers, and supervisors in these developmental efforts.

Warner was an activist and clearly worked in harmony with other educational and political organizations to promote the causes of technology education. As mentioned earlier, he was a master at networking and getting others to support his mission and goals. As such, he would applaud ITEA's demonstrated efforts to collaborate with other professional organizations to promote the study of technology education. However, several associates felt that Warner would have been ambivalent—praising ITEA for its work (e.g., funding successes with NSF and NASA, and consequent standards and curriculum development) but disappointed in its ability to capitalize on these successes in the local and national grassroots political arenas. Warner would probably have liked to see aggressive assistance from ITEA particularly to those local educational agencies and state technology organizations where programs are under siege.

It was also suggested that Warner would most likely have included different representatives as part of his educational and political counsel rather than math, engineering, or science. Some concerns focused on loyalty and creating political support for the continuation or vitality of technology education in K–12. For example, if a state education department recommends the elimination of technology education programs as it announces the continuation of the delivery of technology education experiences as part of science and social science classes, one must ask if there is reason to believe that NSF would intervene to prevent that from happening. And, would independent technology education programs continue to be offered as part of the common school curriculum?

Group V: Other Observations—Accomplishments & Future Expectations

First, we should feel good about our professional accomplishments and progress over the past century as a new academic subject matter has evolved over the past century with roots emerging from the study of manual training, to manual arts, to industrial arts, and now technology education. Instructional programs seemed to be focused and integral to the teaching of "industrial technological" concepts.

Warner would have been open-minded enough (and somewhat self-congratulatory) to see that much of what has been conceptualized since the publication of *A Curriculum to Reflect Technology* in 1947 has been built on the philosophical principles and foundations described in that document. Some notable examples include the curriculum development efforts at Ohio State University, University of Wisconsin—Stout, and University of Maryland in the 60s and 70s and, to some extent, the work reflected in the ITEA-sponsored *Technology for All Americans* project.

But the profession was not "unified" like math or science; and as a result, there was no single voice or agreement as to what industrial arts education or technology education should have been or was to become. Related to this issue is the fact that as a profession, we have not satisfactorily defined technology education or successfully implemented it as part of the school curriculum, thus causing much confusion and a lack of national support for the field.

As such, the profession must coalesce and strive to focus on a core set of subject titles that can be recognized by the general public such as what science has done with its subjects: biology, chemistry, physics, and life sciences. Math has been successful in its own way like science.

The other subject areas have 100 years on us. The public probably only knows us as shop or woods, metals, and drafting. Colleagues must come together to accept the challenge and opportunities to engage in curriculum development based on the 2000 content standards, and perhaps in a few years the public will be able to recognize the difference between technology education and the study of computers.

I am certain that Warner would have faith in the collective intelligence of former students and colleagues with whom he enjoyed sharing the podium in providing leadership education for the profession, especially through the two organizations he helped to create; namely, EPT and the ITEA. Particularly, he would encourage greater political intervention by technology educators to ensure the attainment of common goals. This initiative needs to reach the grassroots organizations and political policy decision makers in all states and, perhaps, it would be beneficial if the ITEA leadership spearheaded such efforts. Other professional organizations such as EPT and CTTE and the Association for Career & Technical Education (ACTE) should also be involved in these efforts. Partnerships with science, math, and engineering educators are a reality and, hopefully, this will become a mutually beneficial relationship.

Doctoral leadership programs in technology teacher education are virtually nonexistent today as evidenced by their closure, severe reductions in program and faculty, and/or changed programmatic focus. This includes most of the prominent universities that graduated the majority of doctoral recipients since World War II, including University of Maryland, University of Minnesota, University of Missouri, Texas A&M University, University of Illinois, Virginia Polytechnic and State University, University of Northern Colorado, University of West Virginia, Arizona State University, and Pennsylvania State University. Thus, Warner would strongly advocate the need for revitalization of our university graduate programs to ensure the operation of teacher education programs as well as preparing the future professorate and leadership.

And finally, leadership must be a "shared" responsibility that involves university faculty, state departments of education, classroom teachers, and supervisors. Professional associations have a responsibility to "serve" the profession and provide support to ensure the delivery and improvement of quality instruction. No one agency, organization, or entity must dominate the process if we are to be successful in managing this professional revitalization of technology education and to ensure quality instructional services to our youth and nation.

Some asked what technology education would be like today without the influence of William E. Warner. From my perspective, technology education might have evolved as a prevocational subject (and not necessarily relegated to that of a step-child of trade and vocational education) complete with federal funding and legislative support without Warner. But given Warner's insights and leadership in creating the AIAA (which later became ITEA) and EPT and an array of curricular-related initiatives, technology education has come into its own. And without a doubt, we would have enjoyed more progress if Warner and his colleagues had worked in harmony to achieve common goals.

In Retrospect

I'm delighted to have been a participant in this dialogue and celebration of the 75th anniversary of the founding of EPT. Warner was a very unique person and it was a bit difficult to get into his head, so to speak. On the plus side, he was very intelligent, professional, an educational visionary, a very successful innovator, and an outstanding leader! He was also thought to be egotistical, self-centered, overly confident, and a "master" at manipulating the power chain to achieve what he thought was important. Nevertheless, he was a "champion" for the evolution and promotion of what we now know as technology education. And as one of his former students suggested, champions are pioneers and often pioneers become popular targets, which he was and clearly his behavior often invited such responses!

One lesson we should learn from studying the professional work of William E. Warner is that the personality and leadership style of those responsible for charting the course of our profession will have a significant impact on the outcomes of any professional initiative they choose to sponsor. As we prepare for creating the technology education program for this new century, let us remind our colleagues of their moral responsibility to reach out and embrace the general membership to share in the refinement of goals and professional initiatives.

Petronius Arbiter said, “… reorganizing … could produce confusion, indifference, and demoralization.” Clearly, these factors have been apparent, not only in technology education but in numbers of other disciplines. Let’s not visit them as negative consequences, but as incentives and motivators to grow and prosper as Warner envisioned the field.

Finally, my expectation is that William E. Warner’s final admonition would be a reminder that this has been and continues to be a *wonderful* profession! And, its future is in your hands, so go forth and be the best you can!

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Ethics for Industrial Technology

Kurt A. Rosentrater and Radha Balamuralikrishna

Abstract

This paper takes aim at one specific, as well as basic, need in teamwork and interdisciplinary projects – ethics and its implications for professional practice. A preliminary study suggests that students majoring in industrial technology degree programs may not have adequate opportunity to formally study and engage in ethical aspects of technology vis-à-vis the practices of the profession. It is reasonable to assume that the ethical dilemmas faced by an industrial technologist would parallel those of engineers and managers. To address this issue, this paper identifies a domain of knowledge that would constitute a necessary background in ethics for industrial technologists, examines various resources for teaching, and makes recommendations from a pedagogical point of view.

Keywords
Curriculum Development, Ethics, Industrial Technology, Professionalism, Societal Obligations

Introduction

The college education of engineers and technologists in the United States in key areas such as construction, manufacturing, communications, and transportation manifests itself in the form of three broad degree programs that can be identified as engineering, engineering technology, and industrial technology. Engineering degree programs have a long history in the U.S., and even though certain misconceptions regarding the profession of the engineer may still exist among the general public, it is fair to state that the profession is relatively well understood among high school students and the public at large.

All fifty states work with the NCEES (National Council of Examiners for Engineers and Surveying) in licensing and maintaining the professional competence of engineers (http://www.ncees.org). Engineering technology and industrial technology, however, belong to a newer class of degree programs that have generally eluded public knowledge (Minty, 2003). The four-year "technology" degree programs have been in popular existence for only the past 30 to 40 years, and currently the professions of "engineering technologist" and "industrial technologist" are not regulated by statutory agencies. Certain states do allow graduates holding engineering technology degrees to qualify for the title of "professional engineer" by examination. To date, however, a degree in industrial technology does not meet the educational requirements to seek licensure in engineering in any of the fifty states. It is also fair to state that the profession of "engineer" is universally understood; however, the terms "engineering technologist" and "industrial technologist" pose significant confusion for many, especially among educators based outside the United States. The fact remains that we have a large community of engineering and industrial technologists in American industry today, and that pool continues to expand on a yearly basis (www.nait.org).

Although much has been said regarding the distinctive competency of industrial technology (www.nait.org/jit/jit.html), there is overwhelming evidence that the industrial technology curriculum shares significant similarities with engineering and engineering technology programs (http://www.nait.org). Not withstanding the existing differences in status and mission of engineering, engineering technology, and industrial technology, students graduating from any of these three programs often serve at the forefront of present and future technical marvels and innovations. At the most fundamental levels, there should be a core body of knowledge that serves to unite the closely related professions of engineering, engineering technology, and industrial technology. From a societal viewpoint, the industrial technologist's responsibility towards safety and public health equals that of engineers. Due to this reason alone, a curriculum designed to prepare industrial technologists should include the teaching of ethics either as a separate course or blended into the curriculum. The rest of this paper is directed towards preparing a more substantial case for the formal inclusion of ethics in the industrial technology curriculum, and even more importantly, discusses implementation strategies for such an endeavor. The importance of ethics to these technical professions is underscored by the emphasis on ethics at the institutional, industrial, and national levels. In fact, during the last five years alone, 78 papers have been presented at the annual national ASEE conferences (http://www.asee.org) that discuss teaching ethics in the engineering and technology curricula.

Current Status of Treatment of Ethics in Industrial Technology

The discipline of industrial technology as we know it today has a relatively short history (Minty, 2003; www.epsilonpitau.org). Even so, significant contributions, both at the national and international levels, have been accomplished by affiliates of the discipline in the core areas of engineering and technology (Helsel, 2004). The National Association of Industrial Technology (NAIT) provides leadership and also provides a platform for its associates to constantly expand both the breadth and depth of the discipline. NAIT is also the official body responsible for accreditation and certification of industrial technology programs. Industrial technology courses often possess an "engineering" flair (e.g., knowledge base) with the caveat that (a) these are generally not as mathematically intensive as standard engineering courses and (b) industrial technology courses tend to be more laboratory oriented with emphasis on experiential learning Additionally, more than 25% of regular faculty members that teach in industrial technology programs today have terminal degrees in engineering (http://www.nait.org). Leaders and experts in industrial technology have acknowledged that the discipline needs to adapt and adopt from the best practices of other closely affiliated disciplines such as engineering and business in order to achieve success (Ward and Dugger, 2002). The accreditation standards for business programs established by the American Assembly of Collegiate Schools of Business (AACSB), and similar standards for engineering, established by the Accreditation Board for Engineering and Technology (ABET), have clearly specified "ethics" in the required content domain (i.e., knowledge base). Moreover, engineering ethics is one of the core areas in the Fundamentals of Engineering (FE) examination, which must be successfully completed by people seeking the status of registered or professional engineer.

Short of conducting a national survey or similar study, an effective means to gain insight into the existing status of ethics in the industrial technology curriculum is to examine the standards for both the accreditation of industrial technology programs as well as the certification exams for industrial technologists. The curricular requirements for NAIT accredited Bachelor's degree programs are summarized by its accreditation Standard # 6.3.5; specifically, Table 6.1 embedded under the said clause (www.nait.org). A study of this section reveals that ethics is not one of the required subject matter competency areas. It is true that some students may receive some background in ethics through general education courses or open electives. However, the wisdom in hoping that a student gains competency in ethics by chance or assuming that they are not going to gain professional benefits from this knowledge is highly questionable. Furthermore, the NAIT certification exam cites four key competency areas: production planning and control, safety, quality, and management and supervision. Here again, competency in ethics is not explicitly stated. It may be worthwhile noting that this national exam for certification of industrial technologists is in its infancy, having made its first appearance in 2003.

Additionally, an examination of curricular requirements across a broad range of NAIT accredited degree programs reveals that very few institutions offer coursework in ethics under the auspices of their industrial technology program (http://www.nait.org). We were unable to single out an industrial technology degree curriculum that mandates a course bearing the keyword "ethics." We realize that this observation in itself does not make a case for the lack of coverage of ethics in the curriculum. However, it may be a strong indicator of the presence of a void, which this paper seeks to address. It is quite possible that several programs assume that competency in ethics will be acquired through general education courses or open electives. We assert that if this is the case, the assumption is likely flawed and attempts should be made to correct this by ensuring that competency in ethics is spelled out as a specific requirement.

Current Needs in Treatment of Ethics

Graduates of industrial technology programs typically accept junior level management roles at the entry level or rise to this level quickly. They often provide a critical link between operating staff, senior management, and the engineering team. As hands-on professionals, they are often not only responsible but also accountable in critical operational areas such as quality approval, workplace hazards and safety standards, compliance with environmental laws, and dealing with customers. Each one of these, as well as other operational areas, could potentially pose a myriad of ethical issues. For example, in the quality approval area, the industrial technologist may have the responsibility to maintain records for continued ISO 9000 certification, approve parts that are either being sold to another vendor or end user, or she/he might be given the authority to approve incoming parts from a supplier. One can easily think of a multitude of ethical issues that relate to these responsibilities including integrity of data, integrity of process, maintaining appropriate confidentiality and privacy. The development of new products and services in the 20th century demand unprecedented levels of interdisciplinary collaboration and teamwork, and the 21st century promises to provide even greater challenges in these areas with attendant ethical issues. The switch to a simultaneous engineering mode of product development requires industrial technologists to be actively involved right from the initial concept design stage, thus posing greater involvement in product safety and environmental issues affecting both the individual workplace as well as society in general.

In a recent study (Helsel, 2004), an effective case was made for establishing a code of ethics for industrial technologists much along the lines of those codes that already exist for engineers, which have been ratified by respective professional bodies, such as NCEES, ABET, AIChE (American Institute of Chemical Engineers), ASCE (American Society of Civil Engineers), ASME (American Society of Mechanical Engineers), ASQ (American Society for Quality), and IEEE (Institute of Electrical and Electronics Engineers). In many ways, this paper complements and bolsters that argument. We agree with the delineated position, but go further to state that accreditation standards for industrial technology programs should clearly specify ethics in the content domain of knowledge and outcomes assessment. Contemporaneously, the Certified Industrial Technologist examination should reflect appropriate testing of a candidate's knowledge and skill in dealing with potential ethical issues of the profession.

Addressing the Needs

The field of industrial technology has had a long history of adapting to the needs of the profession so that it will remain relevant over time. Thus, to help fill this current need in industrial technology programs, several key elements are necessary to consider. Specifically, course content domain, teaching resources, teaching methods, and a subsequent plan of action are all necessary components to successful integration of ethics into mainstream industrial technology curricula.

Content Domain

As a discipline, industrial technology encompasses a distinct body of knowledge which is related to, but separate from, that of traditional engineering. This body of knowledge provides a framework from which to develop a course devoted to industrial technology ethics. An effective mechanism for establishing potential course content is the examination of textbooks which are currently being used. At this time, however, no ethics textbook solely dedicated to the discipline of industrial technology exists. Thus, in order to establish an appropriate content domain for ethics which is applicable to the discipline of industrial technology, an examination of tables of contents from several common engineering ethics textbooks would be useful. These are depicted in Table 1. Throughout the table it is evident that many of the topics covered in engineering ethics texts would be equally applicable to the field of industrial technology as well.

Examining Table 1, as well as delving into the substantive content domains of each of these books individually, has identified several areas of commonality that should be amalgamated and utilized in an appropriate course devoted to the ethics of industrial technology. These themes are outlined in Table 2. As this table delineates, the authors recommend essentially seven major focus areas for this type of course. The course should begin with an introduction to ethics, where the student is introduced to this area of study and why it will be essential for their professional careers. Second, the student should be exposed to the foundations of ethical theory, including a brief history of ethical thought, the major theories that are used, and tools for solving problems with moral dilemmas. Third, the student should understand that industrial technology and design are really applications of formal experimentation, and thus safety and responsibility are essential to this field. Fourth, the student should understand the concepts of risk and safety, because the field of industrial technology has many areas where uncertainty abounds, especially in the design and operations arenas. Fifth, the student should learn about the common rights and responsibilities they will have as both employees as well as professionals upon graduation. Sixth, with globalization becoming ubiquitous in the professional world, the student should be aware of the broad impacts that industrial technology can have, including international business concepts, as well as environmental consequences as a result of technological applications. Finally, the student should be aware of professional codes of ethics for other disciplines. Although the field of industrial technology does not currently have one established, there is momentum building to institute a code that formally delineates the common ethics for this profession (Helsel, 2004).

Teaching Resources

For both instructors who are interested in incorporating individual, specific educational modules into existing industrial technology coursework at appropriate locations during the semester, as well as those who may design and implement entire ethics courses devoted to industrial technology, supporting teaching materials are absolutely essential to success. Therefore, a comprehensive listing of both recent textbooks as well as current websites, many of which provide a multitude of case studies, is provided below in Tables 3 through 6. Moreover, these references are categorized according to the two disciplines that most closely intersect the field of industrial technology, namely, engineering (Tables 3 and 4) and business (Tables 5 and 6).

Teaching Methods

Although teaching the theoretical underpinnings of ethics lays essential groundwork, it should not be an end in itself for an industrial technology course. The main objective of this type of course should be to teach practical information and skills to students, so that once they are part of the work force, they will be able to elucidate and examine the moral issues of specific situations that may arise in their professional careers, and will hopefully have the ability to reach reasonable resolutions. Because of beyond the confines of their own educational settings and personal experiences, and to peer into the challenges, problems, environments, and operating conditions of the real world which, unfortunately, many students are never exposed to until after graduation. Moreover, well-defined, thorough case studies offer students insights into the strengths as well as the frailties of the human condition under the stress of the working world, which they are soon to enter themselves.

Introducing and analyzing case studies in the classroom provides opportunities to teach students how to formally and methodically examine industrial scenarios, and thus hone moral problem solving skills. By using this approach, students can practice discerning relevant facts from opinions, identifying specific moral dilemmas and disagreements, breaking down ethical issues into components, weighing risks and benefits of possible actions, choosing a course of action, justifying this action, and accepting possible repercussions from the choices made (NIEE, 2005).

A challenge for educators is to either develop or find appropriate case studies for use in their own classrooms. The aforementioned teaching resources, which include a fairly extensive listing of textbooks and websites, offer a plethora of case studies. Even though the authors have tried to be exhaustive, many more websites exist which are not listed here, and the reader is encouraged to explore the Internet for more.

Plan of Action

As already discussed, within the context of the industrial technology discipline, the essential need for ethics education is currently not being met. To adequately cover the extensive range of topics relevant to this proposal (i.e., Table 2), the authors recommend a full-semester standalone course. Understandably, not all academic programs will be able to accommodate this addition with all other programmatic requirements currently in place. Therefore, it is beneficial to examine other mechanisms for incorporating ethics instruction, either as individual topics, components, or units that can be used as into specific technical courses (Alenskis, 1997; Arnaldo, 1999; Case, 1998; Krishnamurthi, 1998; Whiting et al., 1998), examining ethical issues during technical problem solving in specific technical courses (Rabins et al., 1996), issues and topics for ethical review during capstone experiences (Pappas and Lesko, 2001; Soudek, 1996), ethics components in coursework dedicated to professionalism (Bhatt, 1993; Fulle et al., 2004), topical seminars (Alford and Ward, 1999), as well as integration throughout the entire curriculum (Marshall and Marshall, 2003; Davis, 1992; Leone and Isaacs, 2001).

Conclusions

The steady growth in the number of industrial technology programs, both at the two-year and four-year levels, during the past thirty years challenges associates of the discipline to constantly look for ways to identify gaps in the existing college curriculum and address these issues to further increase the value of its graduates, bolster their qualities and abilities, and enhance the image of the discipline. Our preliminary research indicates that industrial technology programs should immediately address the lack of a core body of knowledge in ethics specifically aimed to be of service to its students, alumni, and affiliates. Moreover, because this is such an essential area of training, future revisions of the NAIT accreditation standards should specifically include ethics as a core competency requirement, and the Certified Industrial Technologist examination should duly emphasize ethics as an area of testing.

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Table 1: Sample Tables of Contents from Several Contemporary Engineering Ethics Texts

	Textbook				
Chapter	Fleddermann[a]	Harris[b]	Martin[c]	Mitcham[d]	Schinzinger[e]
1	Introduction	Engineering Ethics: Making the Case	Scope & Aims of Ethics	Is Ethics Relative?	Profession of Engineering
2	Professionalism & Codes of Ethics	Framing the Problem	Moral Reasoning & Ethical Theories	Exploring Different Dimensions of Ethics	Moral Reasoning & Ethical Theories
3	Understanding Ethical Problems	Methods for Moral Problem Solving	Engineering as Social Experimentation	Ethical Theories	Engineering as Social Experimentation
4	Problem Solving Techniques	Organizing Principles	Responsibility for Safety	Ethics & Institutions	Commitment to Safety
5	Risk, Safety, Accidents	Responsible Engineers	Responsibility to Employers	Models of Professionalism	Workplace Responsibilities & Rights
6	Rights & Responsibilities of Engineers	Honesty, Integrity, Reliability	Rights of Engineers	Loyalty	Global Issues
7	Ethics in Research & Experimentation	Risk, Safety, Liability	Global Issues	Honesty	Sample Engineering Codes
8	Doing the Right Thing	Engineers as Employees	Engineers as Managers, Consultants, & Leaders	Responsibility	
9		Engineers & the Environment	Sample Engineering Codes	Informed Consent	
10		International Engineering		Ethical Engineering & Conflict Resolution	
11		Professionalism & Ethics		Engineering & the Environment	

Notes:

[a] Fleddermann, C. 2004. Engineering Ethics. Upper Saddle River, NJ: Pearson Education, Inc.

[b] Harris, C., M. Pritchard, and M. Rabins. 2004. Engineering Ethics: Concepts and Cases. Belmont, CA: Wadsworth Thompson Learning.

[c] Martin, M. and R. Schinzinger. 2004. Ethics in Engineering. New York, NY: McGraw-Hill.

[d] Mitchum, C. and R. Duvall. 2000. Engineering Ethics. Upper Saddle River, NJ: Prentice Hall.

[e] Schinzinger, R. and M. Martin. 2000. Introduction to Engineering Ethics. Boston, MA: McGraw Hill Higher Education.

Table 2: Essential Content Domain for an Industrial Technology Ethics Course

Introduction to Ethics
Professional environments for industrial technologists
Design processes
Importance of morals in professional life
Defining morals
Defining ethics • Personal ethics • Professional ethics
Moral dilemmas
Why study ethics?
Codes of ethics • What are they? • What are they used for? • What are their limitations?
Corporate climates and ethics
Ethical Theories and Moral Reasoning
History of ethical thought
Ethics of Utilitarianism
Ethics of Rights
Ethics of Duty
Truthfulness
Virtue
Customs and ethics
Religion and ethics
Self interest and ethics
Professional commitments
Methods for moral problem solving
Design and Technology as Experimentation
Design process as a process of experimentation
Need for responsible experimentation
Accountability in design
Industrial standards for design
Commitment to Safety
Definitions of safety
Risk and uncertainty in design
Personal risk vs. public risk
Assessing risks
Accepting risks
Reducing risks
Accidents
Risk-benefit analysis
Workplace Responsibilities and Rights
Employee relationships
Employee responsibilities
Ethical responsibilities • Minimalist • Reasonable care • Good works
Impediments to responsibilities
Honesty
Integrity
Reliability
Confidentiality
Conflicts of interest
Professional rights
Employee rights
Company loyalty vs. whistle blowing
Global Issues
International business • International corporations and economics • Technology transfer • International values and practices • International rights • Human rights
Environmental Ethics • Status of the environment • Stewardship vs. corporations and industry • Stewardship vs. government • Stewardship vs. society • Stewardship vs. economics and costs
Professional Codes of Ethics

Table 3: Engineering and Technology Ethics Books

Alcorn, P. A. 2001. *Practical Ethics for a Technological World*. Upper Saddle River, NJ: Prentice Hall.
Beder, S. 1998. *The New Engineer: Management and Professional Responsibility in a Changing World.* Macmillan Education.
Davis, M. 1998. *Thinking Like an Engineer: Studies in the Ethics of a Profession.* Oxford University Press.
Fleddermann, C. 2004. *Engineering Ethics.* Upper Saddle River, NJ: Pearson Education, Inc.
Flores, A. 1990. *Ethics and Risk Management in Engineering*. University Press of America.
Flowers, W. and C. Whitbeck. 1998. *Ethics in Engineering Practice and Research.* Cambridge University Press.
Gorman, M., M. Mehalik, and P. Werhane. 1999. *Ethical and Environmental Challenges to Engineering*. Upper Saddle River, NJ: Prentice Hall.
Gunn, A. and P. Vesiland. 2002. *Hold Paramount: The Engineer's Responsibility to Society*. Thompson Engineering.
Harris, C., M. Pritchard, and M. Rabins. 1997. *Practicing Engineering Ethics*. New York, NY: Institute of Electrical and Electronics Engineers, Inc.
Harris, C., M. Pritchard, and M. Rabins. 2004. *Engineering Ethics: Concepts and Cases*. Belmont, CA: Wadsworth Thompson Learning.
Hekert, J. 2000. *Societal, Ethical, and Policy Implications of Engineering: Selected Readings.* New York, NY: Institute of Electrical and Electronics Engineers, Inc.
Johnson, D. 1990. *Ethical Issues in Engineering.* Upper Saddle River, NJ: Prentice Hall.
Johnson, D. 2000. *Computer Ethics*. Upper Saddle River, NJ: Prentice Hall.
Jonas, H. 1985. *The Imperative of Responsibility: In Search of an Ethics for the Technological Age*. University of Chicago Press.
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Low, N. 2001. *Global Ethics and Environment.* Brunner Routledge.
Martin, M. and R. Schinzinger. 2004. *Ethics in Engineering*. New York, NY: McGraw-Hill.
May, L., S. Collins-Chobanian, and K. Wong. 2002. *Applied Ethics: A Multicultural Approach*. Upper Saddle River, NJ: Prentice Hall.
Mitchum, C. and R. Duvall. 2000. *Engineering Ethics.* Upper Saddle River, NJ: Prentice Hall.
Pincus, R., L. Shuman, N. Hummon, and H. Wolfe. 1997. *Engineering Ethics: Balancing Cost, Schedule, and Risk – Lessons Learned from the Space Shuttle.* Cambridge University Press.
Pourciau, L. 1999. *Ethics and Electronic Information in the Twenty-First Century.* Purdue University Press.
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Schlossberger, E. 1993. *The Ethical Engineer.* Temple University Press.
Seebauer, E. and R. Barry. 2000. *Fundamentals of Ethics for Scientists and Engineers*. Oxford University Press.
Severson, R. 1997. *The Principles of Information Ethics.* Sharpe.
Spier, R. 2001. *Science and Technology Ethics.* Routledge.
Spier, R. 2001. *Ethics, Tools and the Engineer.* CRC Press.
Spinello, R. 2002. *Case Studies in Information Technology Ethics.* Upper Saddle River, NJ: Prentice Hall.
Tavani, H. 2003. *Ethics and Technology: Ethical Issues in an Age of Information and Communication Technology.* Wiley.
Unger, S. 1995. *Controlling Technology: Ethics and the Responsible Engineer.* Holt Rinehart and Winston.
Vesilind, P. and A. Gunn. 1998 *Engineering, Ethics, and the Environment*. Cambridge University Press.
Weston, A. 2002. *A Practical Companion to Ethics.* New York, NY: Oxford University Press.
Wilcox, J. and L. Theodore. 1998. *Engineering and Environmental Ethics: A Case Study Approach*. Van Nostrand Reinhold Company.

Table 4: Business Ethics Books

Adams, D. and E. Maine. 1997. *Business Ethics for the 21st Century*. McGraw Hill.
Andersen, B. 2004. *Bringing Business Ethics to Life: Achieving Corporate Social Responsibility*. ASQ Quality Press.
Axelrod, A. 2004. *My First Book of Business Ethics*. Quirk Books.
Beauchamp, T. and N. Bowie. 2003. *Ethical Theory and Business.* Upper Saddle River, NJ: Prentice Hall.
Bowie, N. 1999. *Business Ethics: A Kantian Perspective.* Blackwell Publishers.
Bowie, N. 2002. *The Blackwell Guide to Business Ethics.* Blackwell Publishers.
Bowie, N. and P. Werhane. 2004. *Management Ethics.* Blackwell Publishers.
Boylan, M. 2000. *Business Ethics.* Upper Saddle River, NJ: Prentice Hall.
Callahan, D. 2004. *The Cheating Culture: Why More Americans are Doing Wrong to Get Ahead*. Harvest Books.
Caroselli, M. 2003. *The Business Ethics Activity Book: 50 Exercises for Promoting Integrity at Work*. Amacom.
Cuilla, J. 2004. *Ethics, the Heart of Leadership*. Praeger Paperback.
De Jorge, R. 2003. *The Ethics of Information Technology and Business.* Blackwell Publishers.
DesJardins, J. and J. McCall. 2004. *Contemporary Issues in Business Ethics.* Wadsworth Publishing.
Donaldson, T. and A. Gini. 1995. *Case Studies in Business Ethics.* Upper Saddle River, NJ: Prentice Hall.
Ferrell, O., J. Fraedrich, and L. Ferrell. 2001. *Business Ethics: Ethical Decision Making and Cases.* Houghton Mifflin Company.
Gopalkrishnan, R., P. Iyer, and G. Iyer. 2000. *Teaching International Business: Ethics and Corporate Social Responsibility*. International Business Press.
Hartley, R. 2004. *Business Ethics: Mistakes and Successes.* John Wiley & Sons.
Hartman, L. 2001. *Perspectives in Business Ethics*. McGraw Hill.
Jackson, J. 1996. *An Introduction to Business Ethics.* Blackwell Publishers.
Jennings, M. 2002. *Business Ethics: Case Studies and Selected Readings.* South Western College Publishers.
Johnson, C. 2004. *Meeting the Ethical Challenges of Leadership: Casting Light or Shadow*. Sage Publications.
MacHan, T. and J. Chester. 2003. *A Primer on Business Ethics*. Rowman & Littlefield.
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Newton, L. and M. Ford. 2002. *Taking Sides: Clashing Views on Controversial Issues in Business Ethics and Society.* McGraw Hill.
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Peterson, R. and O. Ferrell. 2004. *Business Ethics: New Challenges for Business Schools and Corporate Leaders.* Sharpe.
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Shaw, W. 2002. *Ethics at Work: Basic Readings in Business Ethics.* Oxford University Press.
Snoeyenbos, M., R. Almeder, and J. Humber. 2001. *Business Ethics.* Prometheus Books.
Solomon, R. 1993. *Ethics and Excellence: Cooperation and Integrity in Business*. Oxford University Press.
Sternberg, E. 2000. *Just Business: Business Ethics in Action*. Oxford University Press.
Sullivan, W. and L. Shulman. 2004. *Work and Integrity: The Crisis and Promise of Professionalism in America*. Jossey Bass.
Trevino, L. and K. Nelson. 2003. *Managing Business Ethics: Straight Talk About How to do it Right.* Wiley.
Velasquez, M. 2001. *Business Ethics: Concepts and Cases*. Upper Saddle River, NJ: Prentice Hall.
Weiss, J. 2002. *Business Ethics: A Stakeholder and Issues Management Approach*. South Western College Publishers.
Weston, A. 2000. *A 21st Century Ethical Toolbox.* Oxford University Press.
White, T. 1993. *Business Ethics: A Philosophical Reader.* Upper Saddle River, NJ: Prentice Hall.

Table 5: Engineering and Technology Ethics Websites

Case Studies in Economics and Ethics in an Early Biomedical Engineering Class – Vanderbilt University, http://www.vanth.org/docs/003_2002.pdf#search='engineering%20ethics%20case%20studies'
Case Studies in Failures and Ethics for Engineering Educators – University of Alabama, http://www.eng.uab.edu/cee/faculty/ndelatte/case%5Fstudies%5Fproject/
CEE 440: Design Seminar – University of Washington, http://courses.washington.edu/cee440/
Center for the Study of Ethics in the Professions – Illinois Institute of Technology, http://ethics.iit.edu/
Center for the Study of Ethics in Society – Western Michigan University, http://ethics.tamu.edu/
Earthquake Engineering Research Institute, http://www.eeri.org/home/programs_ethics_previous.html
Engineering Ethics – University of Virginia, http://repo-nt.tcc.virginia.edu/ethics/
Engineering Ethics Case Studies – Lake Superior State University, http://asl.lssu.edu/ethics/cases.htm
Murdough Center for Engineering Professionalism – National Institute for Engineering Ethics, http://www.niee.org
Murdough Center for Engineering Professionalism – Texas Tech University, http://www.coe.ttu.edu/ethics/ethics.htm
Philosophy 330: Engineering Ethics – Loyola Marymount University, http://myweb.lmu.edu/jkasmith/phil330.htm
The Internet for Civil Engineers, http://www.icivilengineer.com/General/Engineering_Ethics/
The National Center for Case Study Teaching in Science – State University of New York at Buffalo, http://ublib.buffalo.edu/libraries/projects/cases/ubcase.htm#physics
The Online Ethics Center for Engineering and Science, http://www.onlineethics.org/

Table 6: Business Ethics Websites

American Institute of Certified Public Accountants, http://www.aicpa.org/antifraud/spotlight/030409_cases.asp
Business Ethics – Sharon Stoerger, University of Illinois, http://www.web-miner.com/busethics.htm
Business Ethics ca – The Canadian Resource for Business Ethics, http://www.businessethics.ca
Business Ethics Case Studies – Colorado State University, http://www.e-businessethics.com
Business Ethics Center – Junior Achievement Worldwide, http://www.ja.org/ethics/case_studies.shtml
Case Studies in Business Ethics – Gruner & Jahr USA Publishing, http://www.inc.com/guides/growth/20806.html
Center for Ethics and Business – Loyola Marymount University, http://www.ethicsandbusiness.org/index3.htm
Center for Ethical Business Cultures – University of St. Thomas, Minnesota, http://www.cebcglobal.org/
Center for the Study of Ethics – Utah Valley State College, http://www.uvsc.edu/ethics/curriculum/business/
Complete Guide to Ethics Management: An Ethics Toolkit for Managers – Authenticity Consulting, LLC, http://www.mapnp.org/library/ethics/ethxgde.htm
Ethics Case Studies – Sharon Stoerger, University of Illinois, http://www.web-miner.com/ethicscases.htm
EthicsCenter.ca – Canadian Centre for Ethics and Corporate Policy, http://www.ethicscentre.ca/
Ethics Update – University of San Diego, http://ethics.acusd.edu
EthicsWeb.ca, http://www.ethicsweb.ca
The Center for Business Ethics – University of St. Thomas, Houston, http://www.stthom.edu/cbes/

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Arnaldo, S. (1999). Teaching moral reasoning skills within standard civil engineering courses. Proceedings of the 1999 American Society for Engineering Education Annual Conference & Exhibition. Session 1615.

Bhatt, B. L. (1993). Teaching professional ethical and legal aspects of engineering to undergraduate students. 1993 ASEE Frontiers in Education Conference Proceedings, p. 415-418.

Case, E. (1998). Integrating professional ethics into technical courses in materials science. Proceedings of the 1998 American Society for Engineering Education Annual Conference & Exhibition, Session 1664.

Davis, M. (1992). Integrating ethics into technical courses: IIT's experiment in its second year. 1992 ASEE Frontiers in Education Conference Proceedings, p. 64-68.

Dyrud, M. (1998). Ethics education for the third millennium. Proceedings of the 1998 American Society for Engineering Education Annual Conference & Exhibition. Session 1347.

Fulle, R., Richardson, C., and Zion, G. (2004). Building ethics and project management into engineering technology programs. Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition, Session 1348.

Helsel, L. D. (2004). A code of ethics for industrial technology? *Journal of Industrial Technology 20*(4): 1-5.

Krishnamurthi, M. (1998). Integrating ethics into modeling courses in engineering. Proceedings of the 1998 American Society for Engineering Education Annual Conference & Exhibition. Session 2461.

Leone, D., and Isaacs, B. (2001). Combining engineering design with professional ethics using an integrated learning block. Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exhibition. Session 2525.

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Minty, G. (2003). The future history of industrial technology. *Journal of Industrial Technology 20*(1): 1-8.

National Institute for Engineering Ethics (NIEE). (2005). Nine basic steps to personal ethical decision making. Available online: http://www.niee.org/pd.cfm?pt=AECM [retrieved 01 June 2005].

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Pritchard, M. S. (1992). Teaching engineering ethics: a case study approach. Available online: http://ethics.tamu.edu/pritchar/an-intro.htm [retrieved 01 June 2005].

Rabins, M., Harris, C., and Hanzlik, J. (1996). An NSF/Bovay endowment supported workshop to develop numerical problems associated with ethics cases for use in required undergraduate engineering courses. 1996 ASEE Annual Conference Proceedings, Session 3332.

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Ward, C. D., and Dugger, J. (2002). A comparison of selected categories of accreditation standards of NAIT, ABET and AACSB. *Journal of Industrial Technology 18*(2): 1-8.

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Evidence Related to Awareness, Adoption, and Implementation of the Standards for Technological Literacy: Content for the Study of Technology

Jill F. Russell

Over the past twenty years American education has seen many changes, and most notable have been those related to accountability and assessment. One aspect of these changes has been the movement toward more specified student learning outcomes. In discipline after discipline content standards have been developed outlining that which students should achieve as a result of their schooling. The field of technology education has been no exception. Early in the game, in the 1980's, standards for technology education programs (although not for student achievement, per se) were developed. Then in the fall of 1994, the International Technology Education Association (ITEA) initiated the Technology for All Americans Project. This project received grant support from both the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA).

To this point the Technology for All Americans Project has included three phases. Cumulatively the following have been developed: (1) a rationale and structure for technology education (ITEA, 1996); (2) content standards elaborating what K-12 students should know and be able to do with respect to technology (ITEA, 2000); and (3) standards for technology education programs, professional development, and assessment of student achievement (ITEA, 2003). As such, these efforts over the past decade have constituted an important movement for the promotion of technological literacy both within technology education and in related circles.

Although the development of the various standards has been an important task, implementation becomes the critical next step if the standards are to ever reach fruition. The most well-conceived, quality-crafted standards do little good if they sit on the shelf unused. The purpose of this paper is to examine the evidence related to awareness, adoption, and implementation of ITEA's *Standards for Technological Literacy: Content for the Study of Technology* (ITEA, 2000). The standards will be referred to here as *STL*. The information presented is in part related to the data generated through the external evaluation of the Technology for All Americans Project. Methodology will be described briefly and findings reviewed. Conclusions as to progress will then be presented.

Background

A concern regarding the achievement of technological literacy for all Americans is that although technology education has been taught in schools for years, it has often been delivered as a single short course. In that context, there is limited opportunity for significantly influencing the technological literacy of the general public. Yet as the years have passed, technology has advanced at an exponential rate such that it now has a huge impact on life for almost every American. As a result, the citizens of the United States are somewhat handicapped by this heavy reliance upon, but lack of knowledge about, technology. Simultaneously, Trends in International Mathematics and Science Study (TIMSS) testing has revealed math and science achievement among youth in America does not compare well internationally. All of this contributes to a potentially weakened scenario in relation to maintaining the Nation's quality of life, defense, and productivity (National Academy of Sciences, 2002).

In an effort to assess, at a broad level, the American public's views about technology education, the International Technology Education Association sponsored a Gallup Poll on the topic of technological literacy (Rose and Dugger, 2002). A follow up poll was conducted in 2004 (Rose, Gallup, Dugger, and Starkweather). The results of these polls further document the importance of technological literacy. In both national samplings, three-quarters of all respondents indicated they felt it was very important "for people at all levels to develop some ability to understand and use technology." And in general, the respondents felt the study of technology should be included in the school curriculum.

Of course technology educators would agree, and many would argue further that technology education should be delivered within the context of a K-12 articulated model – whether it is taught solely by technology educators, or infused throughout the curriculum and taught by educators in many disciplines. The technological literacy standards movement has helped to create awareness of the need and prompted discussion of the issues. But large-scale implementation will be required to actually move forward in achieving technological literacy by the American populace.

Methods

This article will present data and information collected by this author, and others (see section entitled Related Evidence) regarding awareness, adoption, and implementation of the *STL*. In terms of this author's work, data collection has included both surveys and interviews/observation. At each of the ITEA annual conferences of 2003, 2004, and 2005 a survey of participants regarding their awareness of, and views about, the standards for technological literacy, was conducted. This target group included technology education teachers, elementary teachers, teacher educators, technology education supervisors, and others. In addition, a survey of technology education teacher preparation institutions was conducted specific to the topic of teacher preparation. The data generated from those surveys will be presented herein. A visit to the Boston Museum of Science included observations and an interview with the Senior Vice President for Research, Production, and Development, who provided further information.

Findings

The findings will be presented in accordance with each specific data collection initiative.

Surveys at the ITEA Annual Conference

A short survey about awareness of ITEA's standards for technological literacy was included in the registration packet for all attendees of the ITEA Annual Conference in Nashville (spring 2003) and in Albuquerque (spring 2004). The survey included a brief request for input from the Executive Director of ITEA, and the promise of inclusion in a prize drawing if the survey was completed and submitted. Two hundred and sixty-three of the 1195 conference registrants in 2003 completed and returned the survey (22% of those present at the conference), as did 125 of the total (1042) conference registrants at the 2004 conference (constituting a 12% rate of participation).

Table 1 shares the respondents' familiarity with and views about the *Standards for Technological Literacy.* Familiarity with the *STL* has grown from 57% to 86% from 2003 to 2004 for ITEA conference attendees responding to the survey. The ratings of quality have increased over that time period as well. Although positive initially, with just over one-third rating the *STL* as excellent in 2003, almost half rated the *STL* as excellent in 2004. Likewise, the expectations for *STL* to have a significant impact on technology education and K-12 education in general, both increased from 2003 to 2004 (69% expecting a significant impact on technology education, and 51% expecting a significant impact on K-12 education in general – both in 2004). Opinion was almost unanimous both years as to the perceived importance of *STL*.

As a follow up to item 5 (in Table 1) above, when asked why they felt the standards were important, the respondents provided a range of opinions, including the following representative reasons. They reported that the *STL*: provide credibility, viability, validity, and accountability; serve as a guide; offer goals; enable political momentum; provide a means for communicating with the public; give continuity and standardization for teaching; reflect and explain the best thinking of technology educators; and respond to the fact that technology is integral to life in America today.

Clearly these respondents value the technology education standards, understand and can articulate their importance, and expect the standards to impact both the field of technology education as well as K-12 education generally. As such, a conclusion that some portion of these people may make efforts to incorporate *STL* in their teaching, is likely warranted.

A similar survey was made available at the 2005 ITEA conference (highly visible, at registration area). The survey promised entry into a prize drawing for an Ipod Player. Ninety-six individuals completed and returned the survey of the 1548 conference attendees, constituting a 6.2% response rate. The 2005 survey questions varied somewhat. Those results are presented in Table 2.

Table 1: Survey Results – 2003 and 2004 Conference Respondents' Familiarity With and Views About the *STL*

Question	2003		2004	
	N	%	N	%
1) Are you familiar with the ITEA's *Standards for Technological Literacy*?				
Yes	151	57.4%	107	85.6%
Somewhat	97	36.9%	12	9.6%
No	15	5.7%	6	4.8%
2) How would you rate the quality of the *Standards for Technological Literacy*? (*Note:* "Good" was not offered as a response option in 2004)				
Excellent	90	34.2%	60	48.0%
Very Good	105	40.0%	51	40.8%
Good	42	15.9%	0	0 %
Fair	7	2.7%	6	4.8%
Poor	0	0%	1	0.8%
Don't Know	19	7.2%	6	4.8%
No Response	0	0%	1	0.8%
3) What impact would you expect the *Standards for Technological Literacy* to have on Technology Education?				
Significant Impact	162	61.6%	86	68.8%
Some Impact	91	34.6%	38	30.4%
Very Little Impact	3	1.1%	0	0%
No Impact	0	0%	0	0%
Don't Know	7	2.7%	0	0%
No Response	0	0%	1	0.8%
4) What impact would you expect the *Standards for Technological Literacy* to have on K-12 education?				
Significant Impact	117	44.5%	64	51.2%
Some Impact	126	47.9%	51	40.8%
Very Little Impact	9	3.4%	7	5.6%
No Impact	3	1.1%	0	0%
Don't Know	8	3.0%	0	0%
No Response	0	0%	3	2.4%
5) Do you think the *Standards for Technological Literacy* are important? Why?				
Yes	258	98.1%	122	97.6%
No	2	0.7%	1	0.8%
Don't Know	3	1.1%	0	0%
No Response	0	0%	2	1.6%

Table 2: 2005 ITEA Conference Survey Results

Question	N	%
1) Do you believe the *Standards for Technological Literacy: Content for the Study of Technology* (2000) are having a positive impact upon technology education?		
Great Impact	43	44.8%
Some Impact	41	42.7 %
Limited Impact	12	12.5%
2) Do you believe the *Standards for Technological Literacy* have the potential long-term to improve technological literacy among K-12 students?		
Greatly	73	76.0%
Somewhat	22	22.9%
Very Little	1	1.0%
3) Please provide your opinion as to the quality of the *Standards for Technological Literacy*:		
Excellent	38	39.6%
Very Good	48	50.0%
Fair	9	9.4%
Poor	0	0%
No Response	1	1.0%
4) Are you familiar with *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (2003), also known as *AETL*?		
Very Familiar	27	28.1%
Somewhat Familiar	54	56.3%
Not Familiar	15	15.6%
5) If you answered above that you were 'very' or 'somewhat' familiar with *AETL*, do you think these standards will assist you in preparing for standards-based student assessment, professional development, and programs in technology education?		
Yes	63	65.6%
Not Sure	19	19.8%
No	0	0%
No Response	14	14.6%

The 2005 results were very positive. Most respondents believe the content standards (*STL*) are having a positive impact and have the potential for long-term benefits for K-12 students' technological literacy. Almost ninety percent (89.6% of the 96 respondents) feel the *STL* quality is either excellent or very good. Eighty-four percent say they are somewhat or very familiar with the *AETL*, and approximately two-thirds feel the *AETL* will be useful in assisting them in preparing for standards-based student assessment, professional development, and programs.

Survey of Teacher Preparation Programs

In the spring of 2003 a survey was conducted of teacher preparation organizations. The mailing list was based upon the ITEA's institutional membership category. Fifty-one out of the total list of fifty-nine institutional members represented teacher preparation organizations in the United States. The invitation to participate in the survey was extended by the Executive Director of ITEA to those fifty-one organizations. The primary purpose of the survey was to ascertain the extent to which the teacher preparation organizations were making changes in their programs to reflect the *Standards for Technological Literacy*. Fifteen responses were received, constituting a 29% response rate. Fourteen of the fifteen respondents (93.3%) reported accreditation by the National Council for Accreditation of Teacher Education (NCATE).

Although the data will be presented in the aggregate, the fifteen responding institutions are named here to demonstrate their representativeness: Appalachian State University, Ball State University, Illinois State University, Indiana State University, Mankato State University, Millersville University, North Carolina State University, Ohio State University, Old Dominion University, St. Cloud State University, Southern Utah University, University of Idaho, University of Maryland Eastern Shore, Utah State University, and Valley City State University.

Table 3 describes the participating teacher preparation programs in terms of size. The average number of students enrolled by these institutions was fifty-two students, with an average of eleven expected to graduate that year.

Table 4 presents information on the extent to which these programs have addressed *STL*. It is evident these respondents have gone to great lengths to address *STL* in their programs. Almost all of the respondents indicated they agree that: their program explicitly addresses *STL*, students are required to have a copy of the *STL*, students are required to prepare *STL*-based lesson plans, graduates use *STL* in their teaching, and their faculty are familiar with *STL* and participate in outside-the-department work related to *STL*. The majority of the respondents offer a course specific to *STL*.

Table 5 describes how these teacher preparation programs assure graduates' knowledge and competency with respect to the *STL*. These programs indicated the students study and practice with the *STL* through various courses and field-work experiences, that program changes have been introduced specific to the *STL*, that there are *STL* benchmarks incorporated within the program, and that posters and portfolios reflect the *STL*.

These respondents have updated their programs, student assignments, and expectations to align with *STL*. This has been accomplished in a myriad of ways that could be helpful to others at the point of beginning the alignment process.

Although only 15 responses were received to this survey, these respondents are all very involved with *STL* and the professional development standards. This is likely influenced by the

Table 3: Program Demographics

Question	Range	Mean	Median	Standard Deviation
1) How many technology education undergraduate majors are enrolled in your program?				
	15-200	52.4	40	42.94
2) How many graduates in technology education do you expect for 2002-2003?				
	2-45	11.4	8.5	10.27

Table 4: The Extent to Which the Programs Have Addressed the *STL*

To what extent do the following statements characterize your technology education teacher preparation program?

Statement	N	%
1) The *Standards for Technological Literacy: Content for the Study of Technology (STL)* are addressed explicitly within our program.		
Strongly Agree	10	66.7%
Agree	5	33.3%
Disagree	0	0%
Strongly Disagree	0	0%
2) Our teacher preparation students are required to have a copy of the *STL* for their coursework.		
Strongly Agree	8	53.3%
Agree	6	40.0%
Disagree	1	6.7%
Strongly Disagree	0	0%
3) Our teacher preparation students are required to prepare a lesson plan this is *STL*-based.		
Strongly Agree	8	53.3 %
Agree	7	46.7%
Disagree	0	0%
Strongly Disagree	0	0%
4) Our faculty are very familiar with the *STL*.		
Strongly Agree	9	60.0%
Agree	6	40.0%
Disagree	0	0%
Strongly Disagree	0	0%
5) We have a course that concentrates primarily on the *STL*.		
Strongly Agree	4	26.7%
Agree	5	33.3%
Disagree	6	40.0%
Strongly Disagree	0	0%
6) Our faculty work with state department or local technology education supervisors or teachers in k-12 schools to support implementation of the *STL*.		
Strongly Agree	7	46.7%
Agree	7	46.7%
Disagree	1	6.7%
Strongly Disagree	0	0%
7) Our faculty present on the *STL* outside of department course offerings (e.g. at in-services for a school/district, or at state/regional conferences).		
Strongly Agree	6	40.0%
Agree	6	40.0%
Disagree	3	20.0%
Strongly Disagree	0	0%
8) Our TECA student group has engaged in *STL*-based activities (the statistics for item 8 represent the 12 out of 15 respondents with a TECA organization):		
Strongly Agree	4	33.3%
Agree	7	58.3%
Disagree	1	8.3%
Strongly Disagree	0	0%
9) We would find a user's guide for the *STL* very helpful.		
Strongly Agree	4	26.6%
Agree	8	53.3%
Disagree	26	13.3%
Strongly Disagree	0	0%
No Response	1	6.6%
10) Our graduates make use of the *STL* as the foundation for their teaching.		
Strongly Agree	4	26.7%
Agree	10	66.7%
Disagree	1	6.7%
Strongly Disagree	0	0%
11) Our faculty have identified and implemented expected outcomes specific to the *STL* for teacher preparation students.		
Strongly Agree	5	33.3%
Agree	9	60.0%
Disagree	1	6.7%
Strongly Disagree	0	0%

Table 5: Means of Assuring Graduates' Knowledge and Competency
Examples Provided

1) Students study, evaluate and practice *STL* through all methods, subject areas, and educational coursework
2) Revisions were made to the undergraduate program – changing and/or designing new courses
3) Benchmarks are included in all courses
4) Students are required to prepare lesson plans that include an assessment of those standards being addressed
5) *STL* are addressed through field based and student teaching experiences
6) A poster of the *STL* and state content standards is posted in all classrooms
7) Students are required to complete a portfolio that relates to the standards. They also present a standard in class
8) *STL* are integrated with learning outcomes

Note: Original question was stated as follows – How does your program assure graduates' knowledge and competency with respect to the Standards for Technological Literacy?

fact that 14 of the 15 respondents indicate they have NCATE accreditation, and that NCATE-approved institutions are already in the mode of curricular alignment with various important criteria, such as the *STL*. In addition, the NCATE criteria for technology education programs were developed based on ITEA input. In that sense, it may have been easier for these programs to respond to the questions posed in the survey because they had already taken these steps.

Boston Museum of Science Activity

Another indicator of the impact of the *STL* is evidenced by the activity underway at the Boston Museum of Science. Following are the conclusions from a visit to the Boston Museum of Science where the Senior Vice President for Research, Production, and Development was interviewed (L. Bell, personal communication, March 6, 2004), and a personal tour was offered to the author.

The Boston Museum of Science has been moving from an almost exclusive science focus to a broader science and technology emphasis over the past several years. The museum hopes to serve as a "lighthouse" organization in leading the way within the museum world to technological literacy. They have used the *STL* as an organizing mechanism in their work.

The activities in which they have engaged are ambitious. They include the following (Boston Museum of Science web-site (2005)):

A Star Wars Exhibit is being developed (with help from Lucasfilm Ltd.) which will implicitly address a number of *STL* standards and benchmarks. This exhibit will be constructivist in its approach. It will open first in Boston and will subsequently become a traveling exhibit across the country. Web resources will be available for teachers to use before and after a visit to the exhibit classes.

The museum has established the National Center for Technological Literacy. Its purpose is to: create educational products that promote technological literacy, conduct research about teaching and learning related to technological literacy, and reach out to other organizations to share useful information regarding technological literacy. The Center has multiple means through which it works: (1) advocacy and standard development, (2) curricular materials, (3) an educational resource center, and (4) professional development.

Funding has been awarded to the Museum to develop middle level and high school technology/engineering courses. Teachers are being used in the development process.

The Boston Museum of Science has been "high-profile" in its adoption of the *STL*. The staff have reported on their activities to museum professionals, school professionals, and presented to national audiences. In addition, they have published accounts of their work and progress.

Related Research

Related research has been conducted on awareness, adoption, and implementation of the standards.

In October 2002 Phillip Cardon reported on the "Acceptance of National Standards for Technological Literacy by Technology Teacher Educators" at the Mississippi Valley Technology Teacher Education Conference (Cardon, 2002). Cardon had surveyed 102 institutions offering technology education programs, and received a 51% response rate. His research questions focused on the extent to which the *STL* would provide direction and drive reforms in technology teacher education, and whether or not teacher educators were ready to adopt the new standards.

The survey results shared indicated that at that time almost 30% of the programs had already implemented the *STL* and another 62% were in the process of doing so. The reasons cited for implementing the *STL* included: for program improvement, to address a state mandate to use the standards, to be more competitive, and because the standards were perceived as being "the guiding force" and the "most current approach."

A survey conducted by Daugherty of individual faculty in technology education teacher preparation programs was sent in the fall of 2003 to 123 faculty listed in the *Industrial Teacher Education Directory* (Bell, 2002). A 55% response rate was achieved. The survey was designed to assess: (1) the degree to which technology teacher educators support the *STL* and the corollary professional development standards from *Advancing Excellence in Technological Literacy* (ITEA, 2003), and (2) the extent to which substantial curricular and pedagogical change is viewed as being needed.

Daugherty (2003) found much support for the standards being taught in teacher preparation programs. When the standards were stated, and respondents were asked to rate the agreement with technology teacher education programs preparing individuals to teach those items, all items except two (out of 22) received a mean rating between 4 (agree) and 5 (strongly agree). The highest rated items were: "core concepts of technology," "attributes of the design process," "role of experimentation in problem-solving," and "effects of technology on the environment." The two lowest rated items, receiving a rating between 3 (undecided) and 4 (agree), were "core concepts of medical technologies," and "core concepts of agriculture and biotechnologies." In terms of the perceived need for change, over 62% of the respondents indicated that "major change was called for in the field." Many of those indicating major change was not needed, felt that such change had already occurred.

Survey on the Status of Technology Education in the U.S.

In the spring and summer of 2004 the Technology for All Americans Project staff conducted a survey of the states as to the status of technology education, including use of the *STL*. They contacted the state technology supervisor or their alternates to collect their data. Following are the results regarding *STL* usage (Meade and Dugger, 2004): Forty of the fifty states (80%) reported that the *STL* is used at the state, district, or local level within their state; 14% said that it is not used; four percent said they did not know; and two percent did not respond to the item. In addition, Meade and Dugger reported that more than half of the states indicated they "have either based their own standards and curricular materials on the *STL* or aligned their standards and curricular frameworks with the *STL*."

West Ed/Edward (Ted) Britton Research

A new publication, *Bringing Technology Education into K-8 Classrooms: A Guide to Curricular Resources About the Designed World* (Britton et. al, 2005), shares the results of an NSF-funded project that conducted a comprehensive and rigorous review of curricular materials published since the year 2000. The review specifically examined the extent to which the *STL* were incorporated into major technology textbooks and other curriculum resources. The primary intent of the project was to help teachers in the selection process, but it also provides input as to the influence of the *STL*.

Findings indicate that although there is variation among the new textbooks released since the publication of the *STL*, the books generally do address the standards and benchmarks. Britton notes that some books address certain areas better than others, and that ideally a teacher would have access to several textbooks, so that he/she could make use of the best information and activities from each.

Doctoral Dissertation in Florida

A doctoral dissertation entitled "District-level Predictors of Implementation of the Standards for Technological Literacy in Florida" reported that the extent to which *STL* had been implemented in 60 school districts in Florida was related primarily, among a number of variables, to district enrollment (Loveland, 2003). That is, larger districts were more likely to have adopted *STL*.

Sales of STL

At the point of preparation of this document, almost 15,000 copies of the *STL* have been sold (August, 2005). This figure is above and beyond the distribution of copies as a part of the Technology for All Americans Project dissemination efforts. Although purchase of the *STL* does not guarantee adoption or implementation, it is a prerequisite step.

Standards Specialists

As a part of the Technology for All Americans Project, six technology educators were identified as standards specialists who would be available to districts, states, and professional organizations to provide presentations and workshops on the *STL*. This offering has been in place several years now, and over that time period approximately 85 presentations/workshops have been delivered to almost 3,500 participants. The standards specialists have also authored various articles and supplementary materials in support of the *STL*.

Translation to Other Languages

Since the 2000 publication date, the *STL* has been translated and published in Chinese, German, Finnish, and Japanese (for further information on the international translations, contact William Dugger, Jr. via email: wdugger@iteaconnect.org). It is serving both an international and national role in promoting the use of standards for technological literacy.

Supplementary Materials

Through ITEA's Center to Advance the Teaching of Technology and Science (CATTS) multiple documents have been prepared which serve as supplements to the *STL*. These include curricular materials for various grade levels and specific courses, program guides, and resources to help implement the standards. In addition, there are numerous curriculum development and assessment efforts underway at institutions across the country with funding from such sources as the National Academy of Engineering and the National Science Foundation.

Conclusions

Cumulatively, the data from these various sources support the conclusion there has been extensive activity related to the promotion of awareness, adoption, and implementation of the *STL* since its publication in 2000. Broad awareness of the *STL* among technology educators is fairly certain. Many value the *STL* and believe in its importance; they have purchased materials and participated in professional development. Adoption is claimed in a number of cases in that many states, districts, and teacher preparation institutions have made the choice to align with the *STL*. *STL* is being incorporated in textbooks and curricular materials. Organizations outside the traditional K-16 world have chosen to align their efforts with the *STL*. Internationally there is evidence of interest in the standards. Researchers are looking at the use of the *STL* in teacher preparation, in textbooks, and in school districts. True implementation is an activity that happens primarily behind closed classroom doors, and hence can be less amenable to measurement. But progress in the desired direction is underway.

Any single piece of evidence that has been presented here would likely be insufficient to answer the question of extent of adoption of *STL*. However, in combination, the data are supportive of change taking place. As the choice is made in more and more states, districts, schools, and individual classrooms to orient curriculum and instruction towards the *STL*, the impact on student knowledge and competency will become increasingly evident. This will require, though, continued work in the areas of teacher preparation, professional development, and assessment.

Change in education in America, due to its highly localized nature, can be slow, yet the goal of technological literacy for all Americans appears to be gaining in momentum. Although it may take some time to detect variation in the pattern of responses on a Gallup Poll of the overall adult population (and even so, it could not be attributed exclusively to the *STL*), enhanced K-12 student achievement will likely be demonstrated more quickly. This standards-based reform effort gives clear evidence of progress.

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The Gary Plan and Technology Education: What Might Have Been?

Kenneth S. Volk

This story actually started about 100 years ago and continues today. The cast of characters remains essentially the same, with corporate interests, government, educationalists, parents, and students being involved in ideological debate about education reform. Hope, fear, coercion, intimidation, and promises of a panacea all play supporting roles—with challenges to the status quo and the questioning of tradition remaining common threads throughout this tale.

The Gary plan of “work-study-play” was the brainchild of William Wirt (1874-1938), though largely influenced by the philosophy of John Dewey (1859-1952). Introduced in 1907 to the schools of Gary, Indiana, by Superintendent of Schools Wirt, the Gary plan had organizational and curriculum features that fostered hands-on activities relating to occupations and daily life. It was considered progressive in nature, with an articulated and broad program being offered from primary through secondary grades. The increased notoriety of the plan’s social and financial benefits led New York City to invite Wirt as a consultant to transform its overstretched schools. What followed were several acrimonious years of position papers, posturing, and propaganda by all sides, culminating in a swift end to the plan. The demise of the Gary plan in New York and then slowly in other locales throughout the nation that introduced it raises questions as to what might have been, especially as it accentuated manual arts and training, forerunners to today’s technology education programs.

This article first presents the issues, actors, and events surrounding the Gary plan and associated reform efforts in New York City. The inclusion of manual arts and vocational education as a fundamental feature of the plan also described. On a macro level, the politics of American education is examined as to how other reform efforts have been influenced by various factions. Finally, efforts to improve and change technology education through the recent *Standards for Technological Literacy* (International Technology Education Association [ITEA], 2000) are examined as to their potential for success, based on the outcomes and lessons learned from the past.

New York City at the turn of the 20th century was a growing and dynamic place, full of economic and industrial energy, as well as an influx of new immigrants. According to Bonner (1978), during the first decade, over 70% of the students were classified as foreign-born, with Russian Jews, Germans, and Italians comprising two thirds of the school population. The total school population was also increasing around 5% each year, placing great pressure on the city to complete new schools. Despite being considered “one of the marvels of the world of education” (S. Cohen, 1968, p. 96), the schools were not without problems.

Dominated by Tammany Hall, the political machine of the Democratic Party, the city was noted for corruption and poor management. As the Fusion candidate, John Purroy Mitchel was elected mayor in 1913 and brought a “progressive passion for business-like efficiency” (Mohl, 1972, p. 41) to city government. Mitchel was also sympathetic to reform and progressive efforts in education, which soon became the focus of his administration.

Before Mitchel’s election as mayor, Alice Barrows (later Fernandez) was heading up the *Vocational Guidance Survey* under the Public Education Association (PEA) of New York City. As a private organization promoting progressive educational reform, PEA often advised the Board of Education on matters (S. Cohen, 1964). Barrows studied under Dewey at Columbia University and like Wirt, was greatly influenced by Dewey’s philosophy. One outcome of her review of occupations and the vocational training being offered in schools was the recommendation that all children between the ages of 14 and 16 should receive broad experiences in pre-vocational (industrial) education, so as to meet the “practical demands of industry, be consistent with democratic ideals, and be financially practical for New York City” (Barrows, 1914, p. 230). Barrows also recommended “to make an experiment” for pre-vocational training in elementary schools; and being familiar with innovative approaches used elsewhere, suggested that “it would be most profitable and practical if it were carried out along the lines developed in Gary, Indiana” (p. 230).

William Wirt's "Gary plan" was receiving national attention. Founded in 1906 by Elbert H. Gary, the chairman of United States Steel, the new industrial city of Gary, Indiana, hired Wirt as superintendent, where he quickly developed his innovative school system. Also known as the "work-study-play" or "platoon" system, the Gary plan divided school populations into two groups, so that while one group was receiving the three Rs by specialized teachers, the other studied in specifically equipped facilities such as art, gym, and shop (Rich, 1992). Wirt's program also adopted Dewey's idea of a community within the school, so that in an ideal situation, both elementary and secondary students would be housed in the same school in order to learn from each other. According to Wirt (1937/1995), "the school is a playground, garden, work shop, social center, library, and traditional school combined in one plant and under the same management" (p. 23).

Wirt was also a firm believer in manual arts and training, with industrial school shops situated in each school, but often with the added purpose of allowing students to actually build and repair items for the school. In this way, students would participate "in a real industrial business in an environment similar to the old-time industrial home and community" (Wirt, 1937/1995, p. 32). Students in upper grades would be expected in woodworking shops to perhaps build desks, chairs, bookcases, and cabinets. In the printshops, students would handle all the school's printing needs. Painting, electrical, and plumbing needs were also done by students, but under the supervision of teacher-artisans (R. Cohen & Mohl, 1979). As for girls in the program, they were generally not permitted to do work that was beyond their strength or ability, "but with these limitations assumed, a girl may learn cabinet making, printing, electric wiring and other processes" (Dorr, 1915).

The Gary plan also included the absorption of industrial education into the regular school curriculum, which included elementary school-aged children. With the shops to be distributed throughout the building, it gave children an opportunity to become familiar with them by seeing older children at work. As Rheta Childe Dorr (1915), a social reformer, described in euphoric terms, "curiosity is soon aroused, and it is common to see the little ones with their noses flattened against the glass, peering intently at a carpentry or printing class at work." Children would also be allowed into the shops at regularly scheduled times to help the older students. As Dorr continued, "the dread rule of silence has no part in the Gary system. The little boy asks a thousand questions of the older worker . . . thus helping himself to learn."

Reflecting Dewey's "learning by doing" philosophy, Alice Barrows (1915) explained that activities for an elementary grade student might be to help "the seventh grade boys in the foundry moulding the sand for the casting, learning the names of the tools and taking in with all of his eyes how the castings are made." In an integrated and democratic manner, the upper grade students would also help in the education of the younger students. Table 1 shows a typical fourth grade student's day according to Barrows.

Table 1: Fourth Grade Student Schedule Under Gary Plan

Time	Activity
8:15-9:15	Reading, Writing, Arithmetic. A formal study and recitation period in a regular classroom.
9:15-10:15	Shop work (for three months, followed by drawing, science).
10:15-11:15	History and Geography. Another formal recitation period.
11:15-12:15	Lunch—cooked and served by girls in the cooking class.
12:15-1:15	Reading, Writing, Arithmetic. Another formal study and recitation.
1:15-2:15	Reading, Writing, Arithmetic—Or may substitute for the first three months, music, second three months mechanical drawing, etc.
2:15-3:15	Play—most of this hour is given to free play, although suggested and guided by a playground teacher.
3:15-4:15	Auditorium—fifteen minutes of singing, led by the singing teacher. "The rest of the time children from different classes give in dynamic form some of the things they have been learning in their classrooms." For example, students in the foundry class can tell fourth grade students about a casting or about the different parts of an automobile by the machine classes.

With advocates like Mitchel, Barrows, and Dorr supporting Wirt's program, the plan was introduced in 1914 into two elementary public schools (P.S.)—P.S. 89 in Brooklyn and P.S. 45 in the Bronx—as a test before it was to be expanded. To convert the schools, they first needed to be extended with five-floor additions expected to cost approximately $150,000 ("Fitting School," 1915). Provision was to be made for a foundry in the basement with a cupola. An office for the instructor was also to be included, "in which can be maintained experimental models, drawings, etc." Tool rooms and a room for clay modeling were to be placed adjacent to the foundry. With about 4,000 square feet of additional space, it was to be subdivided into other shops such as woodworking, mechanical drawing, and electricity. The remaining floors were to be used for the homemaking model apartment, science labs, and additional classrooms.

For Mayor Mitchel and his Fusion party's progressive enthusiasm for efficiency, the plan was viewed as having enormous economic benefits, as it could reduce the physical overcrowding of schools and demand for new buildings. This was important, given the serious budget problems the city was facing. For social progressives like Barrows and Dorr, the plan provided a natural environment in which children learned by doing. "Barrows and her friends recognized the technological efficiency of the new school plan, but for them the more efficient school had broader and more humanistic purposes—more freedom, more opportunity, more educational enrichment." "Technology, in other words, was accepted as a given, but it was to be used for humanistic, rather than impersonal business ends" (R. Cohen & Mohl, 1979, p. 64).

However, as this story was unfolding, there were other individuals and groups that were about to voice their opinions about the Gary plan. With the plan gaining momentum to expand to other schools, the strength and resolve of the opposition's opinions and actions also increased. Bonner (1978) described the situation at the time: "For critics, the Gary plan was an issue; for advocates, the Gary plan was a cause. While the former took illogical and even misleading positions in the Gary debates, the latter occupied a high-minded and hamstrung political stance" (p. 154).

One leader of the rising criticism was William Ettinger, the associate superintendent of schools. He initially viewed the plan with enthusiasm after an early fact-finding trip to Gary, Indiana, with the newly elected mayor, but he soon became disillusioned with it as he felt the curriculum changes and costs for equipment were too great (R. Cohen & Mohl, 1979). His "Ettinger plan" for manual and vocational education would have one group of secondary students in school for a week, while the other students would be assigned, in pairs, to real work experiences in a business. At that site, they would receive limited training by the company, vocational counseling, and even a small salary. His plan was also being introduced to several schools and was seen as an alternative (competitor) to the Gary plan for secondary school students. Ettinger was also skeptical of the relative value and limited vocational experiences elementary school students would actually receive.

The Board of Education was also an important player in this debate. Thomas Churchill received his appointment as president of the board from the past mayor in 1913, and like Ettinger, became disillusioned with the plan, but for different reasons (Bonner, 1978). Churchill wanted the board to have more power and not to have superintendents implement policy. However, most progressives wanted "experts" running the schools. As an economic progressive, Mayor Mitchel proposed reducing the number of board members from 46 to 7 for greater oversight and efficiency; but when this initially failed due to the state not backing it, he resorted to other means to secure his agenda. What Mitchel did was to have the Board of Estimate that controlled all public funds deny any increased funding for schools in 1916, thus making the Gary plan the only other logical alternative to the expected overcrowded conditions. Hostility between Churchill and Mitchel then escalated, with Churchill believing the plan was not adequately evaluated and that his board would lose authority and control. Eventually, Mayor Mitchel prevailed, with a smaller board bill passing in the state legislature and a new Mitchel-supporter, William Wilcox, elected as board president in 1916.

Teachers also had their own professional and personal opinion of the plan. For example, the New York City Teacher's Association urged a "go-slow" attitude on implementation, as they were not convinced of the benefits (Bonner, 1978, p. 177). For more selfish reasons, teachers generally objected to the one more hour of work the plan required each day, even though the additional hour was to be used for lesson preparation, not teaching. Principals were also generally not in favor of the plan. While Alice Ritter and Angelo Patri, principals of "Garyized" P.S. 89 and P.S. 45, respectively, would often speak at school parent-teacher meetings about the positive aspects of the plan, there regularly would also be in attendance principals such as William Grady, an Ettinger school supporter, presenting views for the opposition (Metcalfe, 1915a).

Even respected educators such as David Snedden and John Dewey lent their names to the plan. According to Snedden ("Tell of Value," 1917), the two hours a day shop experiences for boys and girls under the age of 11 was "not to make him an expert in any vocation." The plan's "industrial arts . . . afforded the children the opportunity to do things with their hands and by applying their minds to their work meant a growth in experience." Dewey also described the plan in positive terms, even praising the Gary plan in his 1915 book *Schools of To-morrow* (Dewey & Dewey, 1962), despite the fact that he never visited Gary, Indiana. As a professor at Columbia University, he also was a supporter of the plan in New York City. Responding to concerns about the lack of evaluation before it was to be expanded to more schools, Dewey stated, "In my opinion, the work-study-play plan as developed by Mr. Wirt does not need any further evaluation before it is extended to other schools in the city. On the contrary, I am already convinced that its value is established" ("Professor Dewey of Columbia," 1915).

Stoking the fires of this public debate was the members of the press, who made the controversy over the plan daily reading matter. The progressive intellectual Randloph S. Bourne wrote a series of pieces for *The New Republic*, later compiled into a book entitled The Gary Schools (Bourne, 1916). Newspapers would also regularly take positions in the debate. For example, Rheta Childe Dorr would have a daily school page promoting the plan in the *New York Daily Mail*, no doubt due to the new owner of the *Mail* being from Indiana and publishing stories solidly in favor of the plan (i.e., "Visiting Clubwomen Impressed" 1916). *The New York Times* was also publishing stories touting the Gary plan (i.e., "The New School Plans," 1916; Wm. G. Willcox Urges," 1915). Perhaps most influential was the voice of Alice Barrows, now hired as William Wirt's personal secretary. As secretary, she skillfully presented Wirt's agenda and her own progressive philosophy in meetings and to the press. Her twice-weekly *New York Tribune* articles promoting the Gary plan assured *Tribune* readers in the banner header that they "will find in this department a clear and authoritative account of the Wirt school system" (i.e., Barrows, 1915).

On the opposition's side, certainly no individual was more influential than Tristam Walker Metcalfe, who had a daily education column in the *New York Globe*. His earlier public backing of Churchill to head the Board of Education, attacks on the Board of Estimate for its stinginess, and rebuttals to any statement made in defense of the plan were unending. Examples of his position can be seen in the headlines: "Emphasis Put Upon Saving in Buildings and Teachers" (Metcalfe, 1915b), "Less Play Space and Much Less Shop Equipment Provided" (Metcalfe, 1915c), and "Estimate Board is Forcing Adoption of Gary School Plan" (Metcalfe, 1916b).

Trade unions were also against the plan. Some saw it a being a plan devised by Elbert H. Gary or John D. Rockefeller. Regarding the U.S. Steel connection, the city of Gary, Indiana, was specifically built to house the workers, with the schools built on donated land, and the superintendent's work supported by officers of the company. It was thus not surprising unions felt "the entire system was designed to train the children of steel workers to be efficient cogs in the industrial machine" (Gilroy, 1917). R. Cohen and Mohl (1979) also described how unions perceived the Gary plan for New York schools as being "designed to stifle mobility and turn out 'wage slaves' for American capitalism" (p. 46). Adding credence to this perception was that two of Mitchel's appointees to the Board of Education were also associated with the Rockefeller-financed and pro-Gary plan General Education Board—a fact regularly brought up in union meetings about the plan (Bonner, 1978).

The End of the Gary Experiment in New York

For nearly four years, the public debate about the Gary plan raged. On one side were the efficiency progressives such as Mayor Mitchel and the Board of Estimate; social progressives such as Alice Barrows, Rheta Childe Dorr, Randolph S. Bourne, and John Dewey; as well as liberal newspapers such as the *Tribune* and *Times*. On the other side were interests that may be considered more self-serving, with William Ettinger, the associate superintendent of schools; Thomas Churchill, president of the Board of Education, Tristam Walker Metcalfe, writing for the *Globe*; teachers; and unions such as the New York City Teacher's Association. However, it was to be the organization and voice of the parents and students that put an abrupt end to the plan.

The main parent's group leading the charge in favor of the Gary plan was called the Gary School League, organized in 1916. An outgrowth of the Women's Municipal League, the Gary School League consisted of reform-minded women elites, among whom Mrs. John Dewey was the most noted from academia. This group of women presented their views at school meetings, were available for interviews in newspapers, and used automobiles to take visitors to Garyized schools. By the late summer of 1917, the league even sponsored the showing of a motion picture for the public to view what a typical day in a Gary school would be like (Bonner, 1978).

Another group formed in September 1917 to promote the plan was called the Committee on Public Education. While the *Tribune* considered the committee to be "non-partisan" and formed "for the purpose of informing the voters about the constructive work carried on in the schools by the city government during the last four years" ("Voters to Learn," 1917), the Globe labeled it as part of Mayor Mitchel's Fusion campaign committee for his upcoming re-election in November of 1917 ("Tell of Value," 1917). The committee was headed by Michael Friedsam, president of B. Altman & Company, but also included academics such as John Dewey and David Snedden. In their committee statement issued on the subject, they mentioned in the very first paragraph the upcoming election and the other candidates' objective to "create passion and obscure facts" ("Voters to Learn," 1917). They further stressed that "under modern industrial conditions which exist in the most intense form in the world and in New York City, opportunity for recreation and the experience, skill and character development that come from the use of tools . . . must be met by the schools."

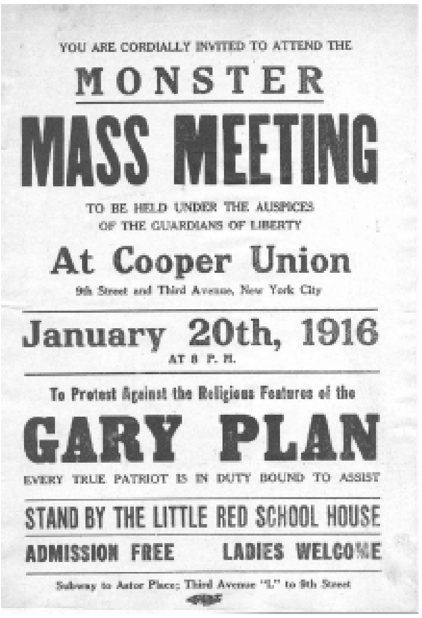
Opposition groups were also being formed. One such group was the Mothers' Anti-Gary League formed by mothers of students attending Garyized P.S. 89 in Brooklyn. Through a petition submitted to the Board of Education and signed by over 400 mothers, objections were raised concerning a number of issues including the neglect of academic work due to the diversity of interests ("Petition Signed," 1916). As noted by R. Cohen and Mohl (1979), many of the other "anti-Gary leagues" that were being formed at schools were actually pushed by Tammany politicians and school principals.

Testimonies by parents were also heard at public meetings to present both sides of the Gary debate. These meetings were often heated and very emotional. At one large public hearing held at the Board of Education, each speaker was to be limited to five minutes. However, the lack of control the president was able to exhibit at this meeting was later explained as "limiting a woman with an hour's worth of conversation to five minutes is sure to enact a certain amount of misdirected energy" ("Two Girl Graduates," 1916). With opposition groups such as Federation of Parent's Association, Mother's Council of the City of New York, School Welfare Association, Bronx Anti-Gary League, Conference of Organized Labor on Industrial Education, and parent's associations from over 10 schools present, the three groups in favor of the plan, including the Gary School League, were vastly outnumbered.

Concerns were also being raised by groups about Wirt's proposal to have release-time religious instruction as part of the plan. With this feature, students were to be released two times per week to attend instruction at their own local church or synagogue. Along with Constitutional issues about the separation of church and state, there were fears students would be pressured by their teachers to attend a specific church, or that they would be ostracized by fellow students for their particular beliefs. One such meeting on this issue was sponsored by the Guardians of Liberty, an anti-Gary group (see Figure 1).

Headlines about the meeting the next day in the Globe stated "Liberty Guardians Accuse Catholics" (1916), while the pro-Gary Tribune's was "Gary Meeting Ends in Disorder" (1916). The Tribune described how "there was considerable confusion when several of the speakers made attacks upon the Catholic Church. . . .

Figure 1. Poster for anti-Gary meeting



YOU ARE CORDIALLY INVITED TO ATTEND THE

MONSTER

MASS MEETING

TO BE HELD UNDER THE AUSPICES
OF THE GUARDIANS OF LIBERTY

At Cooper Union

9th Street and Third Avenue, New York City

January 20th, 1916

AT 8 P. M.

To Protest Against the Religious Features of the

GARY PLAN

EVERY TRUE PATRIOT IS IN DUTY BOUND TO ASSIST

STAND BY THE LITTLE RED SCHOOL HOUSE

ADMISSION FREE LADIES WELCOME

Subway to Astor Place; Third Avenue "L" to 9th Street

It looked for a while as though fists fights would result." One speaker at the rally stated, "I accuse some of the teachers in the public schools of using the schools for the purpose of which they were not intended—that of attempting to make this a Catholic nation."

Despite the propaganda and efforts from both sides, it was the students who actually settled the debate in a very quick manner in the autumn of 1917. With municipal elections scheduled in November, and only 30 out of 680 schools Garyized, the opposition voices became even louder (R. Cohen & and Mohl, 1979). Mayor Mitchel was running again as the Fusion candidate, John F. Hylan as the Tammany candidate, and Morris Hillquit from the Socialist party. Hyland was squarely against the plan, while Hillquit was more neutral and even questioned why many of the best features of the plan were never implemented. Against this heated backdrop, the Gary plan remained at the center of political controversy, but it was the sudden and violent actions of the students that determined the fate of the Gary plan in New York.

The headline in the *Globe* on Tuesday the 16th of October 1917 was "1,000 Pupils Riot Against Gary System." The morning before, a large group of boys refused to go into P.S. 171, a school where the Gary plan was just introduced. Police quickly "rounded up the malcontents and dragooned them into the building." When school ended, the actual riot started, with windows broken and students arrested. So widespread was this anger that even "fathers and mothers encouraged the event" and "girls were taking a leading part."

The next day at P.S. 147, what started out as a meeting for parents and students to explain the Gary plan, also turned into a "riotous anti-Gary demonstration" after the replies to questions were not satisfactory "concerning the practical operation of the plan and the Rockefeller influence upon the public school system" ("Trouble at Gary Meeting," 1917). P.S. 171 problems also continued that day and spread to several other schools. The press immediately placed blame on the Socialists, as signs were waved supporting Hillquit, as well as the chanting of slogans against Mayor Mitchel ("1,000 School Children Strike," 1917). Police estimated the increased numbers from the participating schools were over 4,000.

By the end of the week, the strikes escalated, with an estimated 5,000 students out in the Bronx (Bonner, 1978). Police were injured from stones thrown, resulting in several students being arrested. That next Monday, October 22, things continued to get worse. Several schools in Brooklyn and the east side of Manhattan had demonstrations, with an estimated 10,000 taking part ("10,000 Pupils in Brooklyn Out," 1917). Even at an elementary school in Brooklyn, children smashed windows and were joined by their mothers with banners inscribed "Down with the Gary System" and "Down with Mitchel." Tuesday the 23rd was considerably quieter, with only a few minor incidents at a few schools. However, by that time, it was becoming more evident that Tammany members and their candidate, and not the Socialists, may have had something to do with the events.

While it may never be known whether students acted on their own in order to return to a shorter school day, teachers gave subtle encouragement to their movement, parents desired to protect their children, or political "operatives" instigated the strikes, the riots caused serious damage to the candidacy of John Purroy Mitchel. In two weeks time, he lost the election in a Tammany landslide, with Hylan receiving twice as many votes. Soon after his inauguration, Hylan began to pressure the Board of Education to remove any superintendents who favored the plan in order to expedite the elimination of the Gary plan from schools

("Elimination of Gary Plan," 1918). Recognizing William Ettinger's reputation as an outspoken opponent to the plan, Mayor Hylan swore Ettinger in as the new superintendent that May ("Supt. Ettinger," 1918).

Obstacles to School Reform

Years later, reflecting on the Gary plan, William Wirt (1937/1995) stated, "One must not only recognize that opposition is to be expected . . . as a rule progress is made because of opposition. Sometimes one must recognize that the value of a new proposal can be estimated by the extent of the opposition" (p. 112). As reflected in the example of the Gary plan in New York City, it was very difficult to initiate and sustain change, with teachers in particular very resistant. However, as witnessed by the strength of resolve against it, perhaps there were features of the Gary plan that were of great *potential* value.

Was the Gary plan so flawed and/or had few features that were acceptable that it would never have been accepted? Weischadle and Weischadle (1990) identified the elements of time, trust, team, and training as necessary elements in order to have a chance at successful change. It appears that with the attempted implementation of the Gary plan, little if any of these elements were present. Initially placing the plan in two schools without adequate training for staff, not having the schools fully equipped, then rushing to expand the program to other schools without demonstrating its proven value led to a huge lack of trust. Certainly, attempts were made by the progressives to help educate and convince the teachers and prepare the public, as witnessed by their many public debate appearances and writings for the press. But eventually, these were not enough.

The debate over the Gary plan can also be looked at as a conflict over knowledge and power (Spring, 2002). One arena includes those seeking to have their ideas placed in schools, while another arena wants schools to teach children particular values and ideas. While it is possible these two can overlap, they may also be a source of contention. The actors in New York's different arenas contained politicians, administrative politicians, school boards, progressives, labor unions, corporate interests, groups/organizations, media, the public, parents, and students. Perhaps it was the public's view that schools should be traditional. There was a perception that manual training was part of a "Rockefeller" agenda. Many did not accept the religious instruction feature of the plan. These elements coupled with the frustrations felt by students led to almost insurmountable problems.

As for the teachers' position, Germinario and Cram (1998) described how resistance to change can manifest itself in both subtle and not so subtle ways. Illusions of support, manipulative behaviors, or outright refusal to cooperate are resistant behaviors exhibited in schools. The teachers' reaction to the Gary plan in the early 1900s contained all of these features.

Resistance to educational reform, the agenda of competing interests, and inherent contradictions have occurred in many other educational movements since the Gary plan was introduced in the early 1900s. One example would be reform efforts in the 1960s and 1970s to both increase parental influence on schooling and to reduce racial segregation (Katz, 1987). To implement one policy would require radical decentralization, while the other would lead to larger and more heterogeneous schools. The level of federal initiatives and control over education policy is another area of contention and contradiction. For example, in the 1980s, Republican platforms (Republican Party Platform, 1984) promised fewer federal regulations and less intrusion into local governments, yet initiatives such as the *New American Schools Development Corporation* and *Goals 2000* initiated by President George H. W. Bush seemed to contradict this position. The more-recent *No Child Left Behind Act* developed by the administration of President George W. Bush also reflects, for many, contradictions and fosters a lack of acceptance. The historical role of local schools, the level of funding to adequately support requirements, and the degree by which curriculum and pedagogy change in order to match goals and evaluation pressures are issues raised by this piece of legislature.

Reform efforts in technology education have also had obstacles and contradictions. Since major endeavors in the mid-1980s to transform what had traditionally been accepted and practiced (i.e., industrial arts), there has been a lack of acceptance by teachers (Bussey, Dormody, & VanLeeuwen, 2000; Rodgers & Mahler, 1994), a lack of public understanding (Pearson & Young, 2002), and a lack of understanding by educators (Gray & Daugherty, 2004). Referring to Weischadle and

Weischadle's (1990) elements of time, trust, team, and training as necessary for having successful change, perhaps the limited inroads and health of the technology education profession (Sanders, 2001; Wicklein, 2004) point out deficiencies in meeting some of these conditions.

The recent *Standards for Technological Literacy* (ITEA, 2000) may also face much the same fate as past reform efforts. Will it parallel the Gary plan as a short-lived effort forced into a society with divergent political, administrative, corporate, public, and professional interests that are liable to change, or will it develop into a movement that will transcend differences and stand the test of time? In essence, are the *Standards* a "fad," exactly the same concerns raised at the time about the Gary plan (Metcalfe, 1916a;Vance, 1916)?

Merrill and Comerford (2004) stated that "the use of standards-based teaching and learning has been gaining significant attention . . . [and that] state boards of education are holding school districts accountable" (p. 8). They also confidently maintained that "standards-based instruction is not an educational fad" (p. 8). Despite this optimistic assessment, Wicklein (2004) identified a substantial lack of curriculum consensus about the content of technology education by teachers and university professors. This may suggest that the *Standards*, although presented to the profession for several years now, may still not be universally accepted or implemented. Their genuine acceptance by teachers and the public, as well as how students accept them, will ultimately determine their impact. Time will tell if the *Standards* become a footnote in the field of technology education, just like the Gary plan.

Conclusion

The Gary plan had the potential to be a great influence on technology education. Based on social progressive philosophy that influenced early manual and industrial arts (Petrina & Volk, 1995), it featured many aspects that would be appreciated in today's technology education programs. For example, the Gary plan had all secondary school students involved in technical education, there was clear articulation between elementary and secondary programs, and the school had facilities for the entire school population to use. It also embodied education ideals that centered learning on social conditions and needs through experiential, hands-on activities.

While the Gary plan did not last long, some features of the plan remain in many of today's schools, such as departmentalized teaching in upper elementary grades and an end-of-day "activity period" for students to attend specialized areas in chorus, band, or even technology labs. Had the Gary plan in New York City and elsewhere been successful, instead of technology education programs remaining largely marginalized, they would have remained much more the focal point in schools—and should this have happened, no doubt the health, status, and accomplishments of technology education would be a different story today.

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Electronic Performance Support Systems and Technological Literacy

George R. Maughan

Abstract

Electronic performance support systems (EPSS) can provide alternative learning opportunities to supplement traditional classroom or training strategies. Today's students may benefit from educational settings and strategies that they will use in the future. In using EPSS to nurture the development of technological literacy, workers and students can achieve higher level cognition skills while they perform tasks. Although there are unique challenges to the development and use of EPSS, efforts to overcome these challenges are becoming more widespread.

Introduction

Whether it is planning new highway construction, calibrating a stamping machine, or assembling a tricycle, humans cannot escape using information, tools, energy, and materials when performing a task. Technology has become a powerful force in the world, forming a totality that is difficult to understand as a whole (Ellul, 1954; Winner, 1977; Postman, 1993; Sismondo, 2004). The nature of modern work and rapidly changing conditions in the workplace demand that workers to be very agile in their use of information, tools, energy and materials, and continuously engage in learning.

It is because of this evolving and complex nature of technology that work in advanced technological societies frequently requires skill and knowledge development beyond the scope of standard education and training programs. As tasks become more systemic and highly integrated within a complex workflow, traditional training fails to adequately prepare workers. While traditional training and job aids predominate, increasingly Electronic Performance Support Systems (EPSS) are employed to support skill and knowledge development in real-time and at the work station (Gery, 1995). An EPSS is a configuration of hardware, software, and content accessible by employees or students and structured to provide users with information to permit them to do their jobs or perform tasks with minimal intervention by others. EPSS are an important link between task support, the acquisition of new knowledge and skills, and the development of broader technological literacy (Wittmann & Süß, 1999).

Traditional pre-work and on-the-job training have evolved in such a way that in some cases training is embedded in the work process itself. In the past decade the promise of cost savings and more efficient labor initially provided the impetus for EPSS (Gery, 1995). By eliminating much of the traditional training of workers and providing a smart electronic coach, individuals can use performance support systems to learn while working, and at the same time have instant access to vital support information such as conversion tables, schematics, and flow diagrams. By harnessing computer systems to accumulate information, coach, and respond to user requests, contemporary EPSS are beginning to fulfill their promise of efficiently supporting the performance of tasks. EPSS may deliver even greater benefits than first imagined as these systems actually learn through individual user interaction.

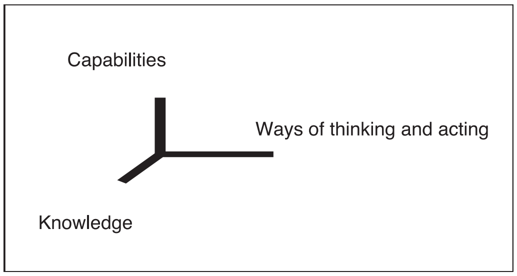
In EPSS, information regarding the performance of technical work is cumulative, expansive, and, as the task is performed, contributes to knowledge constructed by the user. These features are frequently observed in journeymen and master technicians. Performance support systems provide prescriptive information to enable a user to accomplish a task such as locking-up a piece of stock in a vertical milling machine. Expanded information in the form of troubleshooting rubrics, case studies, workflow summaries, and calculation wizards are also provided in the context of the specific task. A user's interaction with this information can lead to higher level thinking and the construction of knowledge enabling the user to realize concrete and abstract concepts and principles (Hambrick, Kane & Engle, 2005). When blended with social learning, scaffolding can contribute to new technical as well as technological literacy both in the workplace and the classroom.

This article explores the relationship between EPSS used to assist workers in the performance of complex tasks and the contributions these systems can make to the development of overall technological literacy. Several themes are discussed. First, the nature of technological literacy is described. Second, electronic performance support systems and how they are used to support work is explored. Third, the role of theoretical constructs within cognition and constructivism and their relationship to the development of technological literacy is discussed. Finally, the challenges faced by trainers and technical educators as they integrate these themes into their work is considered.

Technological Literacy

The National Academy of Engineering and the National Research Council's jointly published book *Technically Speaking*, opens the executive summary by describing "an unacknowledged paradox" (Pearson & Young, 2002, p.1). This paradox is the current low level of technological literacy in the midst of the widespread use of technology. The authors challenge K-12, higher education and adult education to do their part to address this situation. One of the most intriguing aspects of the work is the manner in which technological literacy is described. Three axis: knowledge, ways of thinking and acting, and capabilities are conceptualized. (See Figure 1.) Knowledge represents "knowing about" and being able to recognize the numerous ways technology is represented in our society, including both devices and techniques and large systems, as well as their impacts. Ways of thinking and acting refers to one's participation in asking questions, seeking information and making decisions about the use of technology. Finally, capabilities refer to skills and abilities to recognize and use tools, including such diverse examples as cell phones and programmable control units. This also includes the ability to apply theories and principles.

Figure 1. Dimensions of technological literacy (p.15)



It is within these dimensions that technological literacy develops. Constructivist learning theory suggests that when a user is engaging technology and actively questioning and learning, it is quite likely that knowledge and ways of thinking and acting will develop (Fox, 2001). Through the use of EPSS, employees may construct knowledge necessary to perform complex tasks in the workplace (Wittmann & Süß, 1999). When coupled with social learning, EPSS may assist learners in gaining new ways of thinking and provide greater insight into the larger technological world.

Electronic Performance Support Systems

EPSS exists as **stand-alone** systems or as systems **embedded** in the work process. **Stand-alone** electronic performance support is made available to the user while the work is on-going but requires the user to seek or pull information by querying. Many times this information is displayed alongside work information. A device such as the scan-tool marketed by Snap-on is a good example. This device functions like most scan tools used in automobile service settings by providing troubleshooting codes for malfunctioning engine, transmission, and ABS systems. Yet, this tool goes a step further by providing "troubleshooting" advice to technicians and work-context answers to questions about problems and possible solutions. These functions operate in real-time and can also provide live instrumentation on the actual system in question.

In another example of a stand-alone EPSS application, many Sears service technicians use laptop computers when servicing home appliances. Although the laptop is networked to an external database, the laptop does not directly interface with the malfunctioning appliance. It is quite common to see a technician referring to his/her laptop while diagnosing or repairing an appliance. The laptop communicates wirelessly with the service vehicle parked in the driveway. There the signal is transmitted to a comprehensive database via a satellite link. This communication illustrates the networking of the user's access device with external information. Technicians can check model numbers against parts lists, inventory and price information as well as view diagrams and illustrations.

Finally, another example of a stand-alone EPSS is that of a European automobile manufacturer that employs a "guided fault-finding" system used by service technicians. A laptop computer provides decision-branches for the technician to follow in order to ensure consistency in diagnostic efforts across dealerships. This support system also provides documentation of the technician's work. The system is based on a prompt-and-response procedure that requires the technician to respond at each stage of the guided process thereby tracking workflow. The documentation is then transferred to the technician's memory stick and presented to the service manager for analysis or payment calculations.

Embedded electronic performance support is provided by devices that are interfaced into the work process. They provide suggestions and relevant information to the user during the performance of work by pushing some information to the user as well as responding to user queries. A simple example of an embedded EPSS system is the ubiquitous word processing software that corrects or underlines misspelled words as one types on the computer. Another type of support is the feature that recognizes the task one is performing and offers to provide support via an intelligent agent. For example, when beginning a new word processing document with "Dear Sir," the intelligent agent may query you to offer assistance by displaying a text box that reads, "It looks like you're writing a letter. Would you like help?"

Intuit's Turbo Tax is another example of a user-friendly embedded support system that prompts users for information and is capable of running complex calculations. An on-line example of a relatively powerful embedded system is found at www.expedia.com. Here, the system responds to information the user provides and seeks clarification when necessary before launching a search for airlines or hotels. A complete "vacation wizard" is also available to provide assistance to those who are "vacation challenged."

A unique aspect of stand-alone or embedded EPSS is the wearable feature. Demonstrated in science fiction and action movies, wearable EPSS devices have been portrayed as miniature display panels in glasses or headbands that provide text and imagery along with tiny ear pieces and microphones that provide voice activated commands or instructions. For these systems to qualify as EPSS as described in this article, they would provide only pre-created information, learned information, or real-time information without the intervention of people.

Wearable EPSS systems are no longer relegated to the movies. A few years ago, researchers at Georgia Tech studied the use of stand-alone wearable computers for task guidance in aircraft inspection. The equipment configuration consisted of very small computer with data storage and voice recognition software worn on a belt, a head strap with monochrome display and a microphone. The task performed by subjects using the EPSS was the external preflight inspection of a Cessna 172. Three experimental groups performed the task from memory, using text, or using photographs taken from the operating manual of the aircraft. Although no significant difference was found among the groups, the observable lack of physical contact with the aircraft by the pilots, who seemed to rely heavily on the EPSS to guide their preflight inspection, prompted researchers to suggest additional study of the task context and environmental context when using EPSS so that users will be able to discriminate between interacting with the EPSS and performing the work task (triton.cc.gatech.edu/ubicomp/614).

Regardless of the degree of embeddedness, EPSS consists of twelve possible support structures for workers. Each is tailored to a related set of work tasks, the level of task complexity varying for each. Imagine each of the following being used to support the multi-step task of replacing a residential hot water heater or performing a pre-flight inspection of a single engine aircraft. These structures, adapted from Gery (1995, p. 52), include:

Cue Cards. Single ideas or small sets of facts.

Explanations or Demonstrations. Mini lessons that explain concepts or processes, or graphical presentations of the effect of variables (heat, pressure, time, etc) on materials.

Wizards, Assistants, or Helpers. Sets of queries and prompts that enable the system to perform relatively complex plans or solutions.

Coaches or Guides. Step by step instructors to perform a task.

Searchable Reference. Presentations of glossary, safety precautions, specification charts, tables, and graphs.

Checklist. Mini check lists of flow charts or processes.

Process Map. Graphical representation of flow charts or decision trees.

Examples. Mini cases representing solutions to similar problems.

Templates. Pre-existing solutions to design or process problems.

Tips. Hints to optimize efficiency, avoid problems or to alert users to unique situations.

Practice Activities. Sample problems or exercises to develop skills.

Assessments. Clusters of questions to be used as self-assessment and/or to engage in some type of pin-point diagnostic.

It is apparent that a great deal of effort goes into the creation of EPSS. Of course, more than a single task-set is supported; related tasks may also be supported. The hot water tank replacement task support would probably be accompanied with support structures for related home maintenance tasks such as replacing a kitchen sink and replacing windows. The variety of support structures provides flexibility for individuals who require specific information, yet can accommodate the individual needs of a number of workers.

The degree to which EPSS can support workers or students is influenced by the means of access a user has to the system, and the level of intelligence built into it. Access is influenced by the type of work the system is supporting and the manner through which the user interfaces and navigates within the system. Devices such as optical scanners, keypads, touch-screens, visual displays or voice controlled devices have unique impacts on navigation within the EPSS. Graphical user interfaces that provide alternative views, multiple reference and access points and contextual feedback - all with text and imagery, is desirable. A “text only” default is rarely adequate. Access points and strategies can vary between novice and experienced users frequently requiring multiple pathways to the same information. For example, if an EPSS were available for diagnosing drivability problems on a motorcycle, it could be embedded into a dynamometer (Maughan, 2005) and provide real-time graphical displays of engine performance while identifying faults when the engine is under different loads and supplying the technician with possible repair strategies.

Levels of intelligence built into EPSS determine how adaptable the interface can be and how the system can acquire new knowledge. According to Janet Cichelli, Chief Technologist, SI International, Inc., five levels of intelligence have been described: static, maintained, standardized, dynamic and intelligent (Cichelli, 2004). A static level of information may be information about specifications, procedures, or frequently asked questions/answers associated with the task. As systems are given the capacity to learn, they progress in sophistication by updating changes in the basic information available and creating more standardized task scenarios of “if this, then this.” These features are very useful to typical users. However, it is the top two levels, dynamic and intelligent, that represent the power of EPSS to adjust to various users’ entry levels and link learned information about the user’s experience in relation to the specific task as well as universal task issues. Truly intelligent EPSS may acquire sufficient knowledge to provide suggestions to overall workflow, previous unconsidered efficiencies, as well as simple task completion information.

Constructed Knowledge and Cognition

Training and education activities are informed by various theories of learning. Although a number of theories may apply, the theory that relates most to the fundamental practice of using EPSS to support the performance of workers and develop a broader technological literacy is constructivism. Constructivists view the learner as actively constructing new knowledge drawing upon pre-existing information and past experiences. As experience is gained and knowledge is built, learning opportunities produce new concepts or ideas (Maughan & Anderson, 2005). Most workers are actively engaged in the learning experience. In addition to engagement through doing, reading, calculating and viewing, collaboration with other learners provides alternate perspectives to consider and adds meaning to new knowledge. In addition, learners bring experiences as consumers or hobbyists to the learning process, helping fill in gaps with new knowledge and facilitating higher order thinking.

Fox (2001) explains that learning constructed by the individual can be achieved in many ways and that the paths to learning are not always compatible. The learner may realize the path they decide to take is incorrect and learn from this mistake; thus, the experience of the mistake has assisted in the learning process. Multiple pathways to information need to be provided for different learners. Facilitating the learner's demand for information, when and in what form the learner prefers, is an important function of EPSS.

Learning requires activity and is best facilitated through action. For example, one can better understand the concept of torque if he/she has turned a torque wrench on a bolt and felt the tension while watching the pointer move across the scale. Technology education and vocational and career tech programs have long recognized the importance of this type of active learning. Most industry training programs are also based on a praxis or doing model. EPSS engages the learner by providing highly relevant information while tasks are performed.

The process of turning information as a commodity into knowledge as it is conceptualized by cognitive scientists involves stringent analysis. On a conceptual level, Brown and Duguid (2000) offer three distinctions: 1. knowledge is associated with an individual, 2. knowledge transfer is not easy, and 3. knowledge acquisition requires assimilation based on the knower's "understanding and some degree of commitment" (p. 120). Obviously, to benefit an organization, knowledge must inform practice. In the workplace, that means that knowledge must contribute to the act of work by an individual or through collaboration with workgroups. The third distinction relates to a direct benefit of the use of EPSS since the learner's assimilation occurs within, and because of, the work situation in which the learner is committed to learning en-route to successful completion.

The potential of achieving higher-level cognition from the use of EPSS is probably dependent on the relationship among working memory, short-term memory (STM), and long-term memory (LTM) (Wittmann & Süß, 1999; Hambrick, Kane, & Engle, 2005). STM is influenced by sensory input of information in the common domains of language, text, sights, sounds and smells. This information remains available to the individual for only a matter of seconds or minutes. The variance among individuals may be influenced by their ability to attend and the nature of what is to be learned (Hambrick, Kane, & Engle, 2005).

Repetition or scaffolding techniques applied to information in STM may cause it to become stored as LTM. Once there, LTM is generally not influenced by time – in fact, it can be theorized that once information is accumulated into LTM it may reside there indefinitely. Problems with LTM usually relate to accessing information and integrating smaller bits of information into larger concepts and principles from which higher-order thinking might occur. Furthermore, the cognitive capacity to plan how to apply information from memory to perform a task, known as executive functioning, can influence the overall effectiveness of using EPSS. These cognitive processes become very important to consider in their relationship to the development of technological literacy through the use of EPSS.

One way LTM may be accessed and integrated is through interaction with others. By communicating across the workgroup, the assimilation of information can result in the evolution of various levels of knowledge (Lave & Wenger, 1993). In their recent book, Salas & Fiore (2004) postulate that a key to understanding work process and performance is team cognition, the collective level of thinking within a group. Recent evidence supports that there exists "direct and indirect relationships between team effectiveness and various operationalizations of common cognitions among team members (Rentsch & Woehr, 2004, p.11).

The construction of technological literacy through the use of EPSS requires an understanding of work tasks, cognitive functioning, and design principles for electronic performance support devices, software, and interfaces. The social learning that occurs in a work or learning environment contributes to individual high-level thinking and team knowledge. Although these variables and subsequent systems are often considered in the workplace, it is important to recognize the potential of EPSS in schools. Most certainly the development of performance systems in business would look different than those in schools (Sleight, 1992). Educators are encouraged to think about the comprehensive nature of EPSS development and select those features and systems that can be created and used in settings that do not have the resources or infrastructure for fully developed systems.

Challenges

Although the challenges to trainers and teachers developing and using EPSS are many, the following describes four categories.

Communication and computer infrastructure

The creation of a seamless EPSS information infrastructure comprised of user access devices, networks, developer skills, application policy, and financial support is a challenge to many organizations (Maughan, 2001). The provision of access terminals or nodes may vary from cabled bench-top computers to wearable wireless devices. Network capacity could range from delivering text-based information to full-motion video warehoused in multi-layered databases and connected to real-time process data. In most cases, the speed of data transfer is very high in order to accommodate multiple simultaneous users. This capability is best served in large organizations by their enterprise system. In such cases EPSS users must undergo training to be able to access the system at a level of proficiency necessary to acquire support for the tasks they perform. In addition, if voice interface is a feature of the EPSS, the user must teach the system to recognize his/her voice.

EPSS development generally requires a multidisciplinary team approach. The situation and degree of use of EPSS must be clarified through policy in order to optimize the potential symbiosis between the EPSS and the user, so that inappropriate application will not result in decreased efficiency in the work process. Structural changes in an organization may occur as trainers and teachers move from a linear paradigm of instruction (training followed by application to work), to a paradigm that includes the traditional linear model as well as models where employees or students also construct knowledge through experience or with the support of performance systems while doing work. Financial resources must be in place for the purchase, development, and maintenance of the system. Alternatives to fully integrated communication and information systems are available to most trainers and teachers. The most fundamental of these are hand held and desktop computers.

Knowledge management

Knowledge management is also a challenge to organizations moving towards the integration of EPSS. EPSS requires that relatively large amounts of knowledge be sorted and organized into smaller chunks and placed in the appropriate contexts of particular work processes. This can be difficult for trainers and teachers. Traditional industry and school curricula tend to treat content in an abstract or formal epistemological fashion independent of applications or work settings. Knowledge management in the support of task performance must be derived from the activity and involves identifying and capturing knowledge, indexing knowledge, and making knowledge available to users in flexible and useful ways (Siemens, 2004). Furthermore, it must be acknowledged that the practice of communicating knowledge across an organization depends on the varying communication patterns of workgroups, that in practice, also vary greatly from organization to organization.

Usability

Trainers and teachers tend to develop an unscientific assessment of the knowledge learners bring to the task of learning advanced or relatively new content. For any task, learners can be categorized in terms of possessing prerequisite knowledge as basic, intermediate, or advanced. This assessment can be verified with pre-test or screening instruments, although this is rarely done in education or industry environments. The task for developers of EPSS is to envision multiple access points within the process during which task support is offered – some at very basic levels, continuing in hierarchical fashion to very advanced levels of entry skills, knowledge and ability. In many cases this is not merely an investigation into a linear continuum of difficulty, but often requires the integration of related attributes and concepts fundamental to achieve success. Ideally, as workers or students perform iterative tasks, information corrections as well as new information needs should be provided to developers so that the support structures can be improved for the next execution cycle (Darling, Parry & Moore, 2005).

Presentation

Performance specialists frequently refer to “The Performance Zone” when developing EPSS (Dickelman, 1995; Degler & Battle, 2001). This zone is the center of a venn diagram that consists of three slightly overlapping circles. These three critical elements enable performance: information appropriate to the task, information appropriate to the person and information containing critical features of the world. By ensuring that each of these features are integrated through the means of a graphical user interface, an EPSS can optimize the efficiency of the support provided to workers or learners. EPSS developers must create a virtual world of work without omitting major human attributes (Dickelman, 1995). As sophisticated as a cleverly designed screen may look, the integrating of information needed to enable a worker to make a decision boils down to presenting the totality of the task, not just bits of information. In essence, the EPSS must process information based on the immediate task and the demands of the user.

Conclusions

Certainly the improvement of organization and individual performance requires a focus on the structure of work and workforce training. Because work task performance generally requires the application of specific skills and knowledge, training often focuses on this level of employee learning at the expense of developing a broader technological literacy. Some argue that this approach might limit decision-making and innovation. Improving human performance through the development of specific skills and knowledge, in addition to broader technological literacy has been a major goal of practioners and researchers. Furthermore, efforts to understand the relationship between support structures for the development of specific skills and knowledge to perform tasks and the development of high cognition levels are on-going. The many disparate attempts to characterize learning organizations and high performance workplaces illustrate this point.

Traditional approaches to developing technological literacy through formal education and training programs must continue and expand. However, EPSS can provide alternative learning opportunities to supplement traditional classroom or training strategies. Today's students may benefit from educational settings and strategies that they will use in the future. In using EPSS to nurture the development of technological literacy, workers and students can achieve higher level cognition skills while they perform tasks. Although there are unique challenges to the development and use of EPSS, efforts to overcome these challenges are becoming more widespread. Additional research in this area could provide trainers and educators with new strategies and tools for performance enhancement.

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Computer Assisted Fluid Power Instruction: A Comparison of Hands-On and Computer-Simulated Laboratory Experiences for Post-Secondary Students.

Scott B. Wilson

Introduction

Despite demand from industry, there has been a general lack of emphasis placed upon course content in fluid power by post-secondary educational institutions in this country. The cost of development for the required laboratory facilities is often cited as a major obstacle to fluid power content development.

There is considerable recent research on the use of computer assisted instruction and computer simulation for technical training. Some of the areas that have been studied include the teaching of subjects such as: Electricity and magnetism (Chou, 1998), electrical operational amplifiers (Dobson & Hill, 1995), basic electronics (Moslehpour, 1993), engineering fluid mechanics (Engel et al., 1996), basic thermodynamics (Buttles, 1992), chemistry (Grosso, 1994), engineering physics (Chien, 1997), military pilot training (Andrews et al., 1996).

Much of this research has also been tied to individual differences in cognitive learning styles. In a 1994 review of literature, Moldafsky and Kown reported that cognitive learning style can be responsible for a person's lack of ability to process information from computers, along with their attitude and anxiety towards computers. Additional studies found that individuals with certain cognitive styles could significantly out perform others when asked to recall material presented using computer-based instruction (Hsu, Federick & Chung, 1994; Burger, 1985). There has also been considerable research to link cognitive learning style to a student's choice of a major and achievement within that major (Witkin, 1973; Witkin et al.,1977a; Gregorc, 1979; Garger & Guild, 1984; Torres & Canno, 1994; Garton et al., 1999).

The fluid power industry has had difficulty in achieving the professionalism and formal educational system found in many other engineering and technical fields. The high cost of training equipment may contribute to this problem (Luzerne County Community College, 1987). The small amount of available literature pertaining to fluid power education is a strong indication of the lack of emphasis that this subject area has historically received.

The literature review also indicated that a selection of fluid power computerized design and simulation software is now available. Various software programs can be used to perform computer aided design and testing of circuitry, or even complex engineering analysis of dynamic systems and component selection. Computerized simulations used for instruction can assist the student in developing mental models of many different types of complex systems (Mayer, 1989; Mayer & Sims, 1994; Munro & Towne, 1992; Perkins & Unger, 1994). There is a gap in the literature in terms of the application of computerized simulation to train people for the fluid power industry, which could result in a large reduction in the implementation costs of such a program. The certification levels offered by the Fluid Power Society (FPS) have brought the industry some much needed industry recognition. It is time for the educational community to focus on the need to offer courses in fluid power on a more consistent basis.

Purpose

The primary purpose of this study was to examine the effectiveness of utilizing a combination of lecture and computer resources to train personnel to assume roles as hydraulic system technicians and specialists in the fluid power industry. This study compared computer simulated laboratory instruction to traditional hands-on laboratory instruction, in terms of effectiveness.

Method

This study used a within-subjects repeated measures design to determine the relationship between two methods of teaching fluid power laboratory experiences and student achievement on a cognitive written instrument, as well as a performance (psychomotor) instrument. As secondary research areas, the study examined the relationship of cognitive learning style (field-dependant or field-independent), as well as the sequencing of the laboratory assignments, to the level of student achievement on a performance (psychomotor) instrument.

Four sections of the same college course, with a total of 70 subjects, participated in this study. After receiving the same lecture at the same time, the subjects in each course were randomly split into two treatment groups. Group B completed the first two laboratory assignments using the traditional hands-on fluid power trainers, while Group A completed the first two laboratory assignments using the computerized fluid power simulation program. Upon completion of the first two laboratory assignments, the performance instrument was individually administered to each student.

The performance (psychomotor) evaluations were given using a criterion- referenced instrument at the completion of the first two laboratory assignments and prior to switching to the other type of trainer. The student could receive a score of zero to three points on the performance evaluation, with one point awarded for each of the three required tasks which were completed correctly within the 15 minute time limit.

Upon completion of the mid-lab performance test, each of the groups switched to the other type of laboratory trainer so that all of the students experienced both the hands-on trainers and the computerized simulation program. Upon completion of both treatments, the performance (psychomotor) test was re-administered to each subject individually. At the completion of the course, the Group Embedded Figures Test (GEFT) was administered to all of the students to determine the cognitive learning styles (field-dependant or field-independent) of each subject.

Separate t-test procedures were used to determine differences in actual student performance between the two treatments, as well as to examine the relationship between learning styles (high or low GEFT scores) and performance scores between the treatment types. Additional t-tests were conducted to determine if the sequencing of the treatments resulted in differentiated student performance as well as to determine if there was a relationship between student final performance scores and learning styles (high or low GEFT scores). A paired t-test was conducted to determine if there was a significant difference between mid and post performance test scores and the sequencing of the treatment types. The last statistical analysis involved using another t-test to determine if there was a significant difference between the sum of the two unit exam scores and the sequencing of the treatments.

Findings

The findings of the study which are of value to educators are as follows;

1. There was not a statistically significant difference between the performance of the two treatment groups on the psychomotor instrument after the completion of the first two laboratory assignments.
2. The subjects classified as field-independent learners scored statistically significantly higher on the mid-lab psychomotor performance test than did the field-dependent learners.
3. There was not a statistically significant difference in student performance on the post-lab psychomotor performance evaluation as a result of the sequencing of the treatment types between the two groups.
4. The subjects classified as field-independent learners scored statistically significantly higher on the end-of-lab psychomotor performance test than did the field-dependent learners.
5. The difference between the mid- and post- psychomotor test scores within each group as a result of the two different methods of treatment sequencing was not statistically significant.

Table 1: The Research Design

	Treatments:	
Groups:	**1st & 2nd Lab Assignments:**	**3rd & 4th Lab Assignments:**
Group A	Treatment I: Computer-Simulation Labs	Treatment II: Hands-on Trainer Labs
Group B	Treatment II: Hands-on Trainer Labs	Treatment I: Computer Simulation Labs

6. There was a statistically significant difference in the sum of the cognitive unit exam scores between the subjects in the two different treatment groups. Treatment Group B, which completed the hands-on exercises before completing the computer simulation exercises, had a higher mean score.

Conclusions

The conclusions from this study may be generalized to the population from which the sample was drawn. This study examined the use of computerized simulation for teaching basic fluid power circuitry, and not its use as a tool for engineering analysis of hydraulic or pneumatic systems. Specific conclusions of value to educators are as follows;

1. Similar results can be achieved on a psychomotor performance evaluation whether the instruction is given using a computerized simulation program or a traditional hands-on trainer to teach basic fluid power circuitry.
2. Where both computerized simulation and hands-on trainers are used for fluid power instruction, the sequencing of the two types of laboratory instruction results in similar student psychomotor performance.
3. Students classified as field-independent learners perform better on psychomotor performance tests on basic fluid power circuitry than those classified as field-dependent learners.

Discussion

The finding that similar results can be obtained on a hands-on psychomotor evaluation using computerized as compared to hands-on laboratory instruction is contrary to conventional educational practice in the specific field of fluid power. While computerized laboratory instruction may never replace traditional hands-on laboratory instruction, it could offer similar student performance results where financial or physical constraints prevent the purchase and use of hands-on fluid power trainers. The potential impact of this finding could include an increase in the number of colleges and universities who are able to afford to develop and offer courses in basic fluid power by utilizing existing computer laboratories. In addition, the greater portability of lap-top computers when compared to hands-on fluid power trainers (which often weigh several hundred pounds and cost several thousand dollars each), could encourage more on-site fluid power courses to be offered away from the main campus. Through the use of a server to allow student access to the simulation program, it may be practical to offer a fluid power course in a distance-leaning format.

The lack of difference in performance on the end-of-lab psychomotor test of the two groups indicates there is no difference in the sequencing of the hands-on and computerized stimulation laboratory instruction. However, this study only examined a 50% to 50% split of the two types of laboratory instruction.

Subjects classified as field-independent (FI) learners did achieve a statistically significant higher score on the mid- and post-psychomotor test than did the field-dependent (FD) learners. An earlier study found that field independent (FI) learners were better able to mentally restructure information than field dependent (FD) learners (Wilkin et al., 1977). In addition, FI learners were found to be better able to recall material presented using computer based instruction (Hsu et al., 1994; Burger, 1985). This finding may also have implications for the level of degree that a technical student is seeking. A 1995 study by Hansen determined that the learning styles of four-year post-secondary technology students were more field independent than their two-year counterparts.

This study also found that treatment Group B, which completed the hands-on exercises before the computer simulation, attained a higher mean score on the sum of the unit exams as well as each unit exam separately. However, as the first unit exam was given before the treatments began and the second unit exam was given after the treatments were finished, the impact of the significant difference of the sequencing of laboratory assignments on the outcome of this study is minimal.

Applications for two and four year post-secondary technical programs

While traditional-hands on training will likely still continue to be the preferred method of conducting fluid power instruction, this study has shown that satisfactory results can be achieved using a computerized simulation program. It should be pointed out that unlike a computer-aided design program, a simulation program allows the student to see the system operate, and thus verify, the control logic of the circuit. This study utilized the Automation Studio software package from FAMIC Technologies, (www.automationstudio.com). In addition, supporting fluid power training material can be extremely helpful when explaining fluid power operational principles. A partial listing of sources of fluid power training materials includes: the International Fluid Power Society (www.ifps.org), National Fluid Power Association (www.nfpa.com), Eaton-Vickers Corporation (https://web.fluidpower.eaton.com), Rexroth Hydraulics (www.boschrexroth.com) and Parker-Hannifin (www.parker.com/training).

Basic fluid power trainers can cost from $10,000 for a Vickers unit to almost $15,000 for a Parker unit. Typically two students can use one of these trainers at the same time, producing an equipment cost of $5,000 to $7,500 per student. The cost of developing a computerized simulation lab for fluid power instruction is normally much lower. A six copy package of the Automation Studio software is priced at approximately $650 per copy, which combined with an average price of $1000 to $1200 for a computer package yields a cost of approximately $1600 to $1800 per work station. If two students are paired up on each computer station the equipment and software costs can drop to $800 to $900 per student. Thus, developing a fluid power instructional laboratory can be accomplished at approximately 1/3 to 1/6 of the per student cost of developing a similar sized lab using traditional hands-on fluid power trainers.

While professionals in the fluid power field often express a concern for the loss of hands-on skills when computers are used to teach laboratory applications, a blend of hands-on and computerized-simulation based training for fluid power instruction seems to be the best alternative. When available, a basic hands-on fluid power trainer can be a very valuable tool to teach the basic circuitry and troubleshooting. Complex fluid power circuitry can often be more easily taught using a simulation program. While the Automation Studio package does include detailed drawings of hydraulic components, actual cutaways of the various valves, pumps and motors prove to be an excellent teaching tool as well. Fluid power component cutaways are available from the training departments of the corporations listed above. In situations where the funds for a full complement of hands-on fluid power trainers are not available, computerized simulation packages can provide a low-cost alternative while still being able to offer this important educational opportunity to our students.

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Books Briefly Noted

Allen, M.T. & Hecht, G. (2001). *Technologies of power: Essays in honor of Thomas Parke Hughes and Agatha Chipley Hughes*. Cambridge, MA: The MIT Press. ISBN: 0-262-51124-X, $30.00.

This collection explores how technologies became forms of power, how people embed their authority in technological systems, and how the machines and the knowledge that make up technical systems strengthen or reshape social, political, and cultural power. The authors suggest ways in which a more nuanced investigation of technology's complex history can enrich our understanding of the changing meanings of modernity. They consider the relationship among the state, expertise, and authority; the construction of national identity; changes in the structure and distribution of labor; political ideology and industrial development; and political practices during the Cold War. The essays show how insight into the technological aspects of such broad processes can help synthesize material and cultural methods of inquiry and how reframing technology's past in broader historical terms can suggest new directions for science and technology studies.

Angel, S. (2004). *The tale of the scale: An odyssey of invention*. New York, NY: Oxford University Press. ISBN: 0-19-515868-7, $28.00.

"Either things go according to plan, or there is a story." So begins *The Tale of the Scale*, a rare first-person account of the process of invention and design as it unfolds in the remaking of a familiar bathroom scale. It is rare because inventors seldom have the inclination or the ability to articulate their thoughts and to recount their experiences in great detail. Angel, an urban planner by profession and internationally recognized authority on housing policy in developing countries, had no mechanical skills as he embarked on his journey. This book records his transformation, over the course of a decade, from an amateur to an expert on a thin scale, a travel scale. Readers know as much about scales – or about invention for that matter – as Angel does at the beginning of the journey.

The pursuit of the small scale took Angel to fascinating places – from Bangkok to Rolling Hills, California, from Groningen in the Netherlands to Murrhardt in Germany, and from New York to Tokyo. For Angel, these places became realms of knowledge inhabited by people with diverse yet complimentary outlooks on the invention process – engineers, designers, lawyers, product development specialists, corporate functionaries, and friends who philosophize on the deeper meanings of one's life pursuits.

For anyone who has ever strolled down the aisles of IKEA and dreamt that they too could invent a superb object for domestic use, *The Tale of the Scale* will provide advice, humor, caution, inspiration, and above all, a good story.

Berner, G. (2004). *Management in 20XX: A holistic view of what the future holds*. Erlangen, Germany: Publicis Corporate Publishing. ISBN: 3-89578-241-6.

The whole world is witnessing radical economic changes. Traditional markets are stagnating; global markets are emerging. Business processes are becoming more mobile, more flexible, and much more streamlined. The boom companies of yesterday have disappeared from the scene. Such an environment calls for innovative ideas - for new ways of doing business, for new products and services, and for a totally new world.

To survive, companies will have to be resilient and yet adaptable. To turn their visions into reality, they will have to act as well as react. Growth will come to only those companies that can identify demand and apply the right technological know-how to create tangible customer benefit. Development, marketing, and sales departments must arrive at the right strategies, just as corporate organization, production, and logistics managers must devise and implement the best possible processes.

The book lays out some remarkable scenarios and ambitious visions for the future. It helps readers to formulate ideas and plot new directions for their business and points out the changes needed to meet challenges that lie ahead. The new role people will play in the evolving world of business also receives attention in this book that is at once informative and inspiring.

Bizup, J. (2003). *Manufacturing culture: Vindications of early Victorian industry*. Charlottesville, VA: University of Virginia Press. ISBN: 0-8139-2246-1, $39.50.

From Robert Southey to William Morris, British social critics in the Romantic tradition consistently stigmatized industry as a threat to aesthetic or humanistic "culture." Joseph Bizup, Associate Professor of English and Comparative Literature at Columbia University, argues that early Victorian advocates of industry sought to resist the power inherent in this opposition by portraying automatic manufacture itself as a culture force or agent. He traces the contours of this new proindustrial rhetoric as it coalesced in two mutually reinforcing discourses: The contentious debate over the factory system and its social consequences that raged throughout the 1830s and 1840s, and the extensive discussions of the social and commercial benefits of good design that culminated in the Great Exhibition of 1851.

Through careful readings of a diverse array of texts, including treatises on factories and machinery, medical studies of the working classes, theoretical discussions of the decorative arts, and lectures on the Great Exhibition, Bizup shows that liberal proponents of industry such as Andrew Ure, Charles Babbage, James Phillips Kay, and Henry Cole aestheticized manufacture by interpreting its concrete agents and products – whether they be factory operatives, systems of machinery, mass-produced copies, or elaborately crafted "art manufactures" – as emblems of a prior conceptual unity or beauty. They thus allied industry with culture by portraying industry as one realization of the organic ideal central to the idea of culture. Bizup concludes with an examination of John Ruskin's and William Morris's efforts to counter this sort of rhetorical maneuvering by treating cultured manliness as a figure for the cooperative impulse they both hoped would replace competitive self-interest as a society's organizing value.

By showing that culture could not be opposed to industry in any pure or absolute sense, *Manufacturing Culture* both enriches our understanding of the Victorian debates over industrialization and contributes greatly to the ongoing scholarly exploration of the complex genealogy of our modern concept of culture.

Bowden, M.E., Crow, A.B. & Sullivan, T. (2003). *Pharmaceutical achievers: The human face of pharmaceutical research*. Philadelphia, PA: Chemical Heritage Press. ISBN: 0-941901-30-0, $30.00.

Teachers today want to present the human face of scientific and industrial research, to point to the real people who had the insights and made the major advances that students are asked to understand. This collection of photographs and biographical information makes it easy for teachers to show the human side of pharmaceutical research. The format and special binding of the book allow for easy conversion to overhead transparencies and other media.

Brantingham, P.J., Kuhn, S.L. & Kerry, K.W. (2004). *The early upper Paleolithic beyond western Europe*. Los Angeles, CA: University of California Press. ISBN: 0-520-23851-6, $75.00.

This volume brings together the research of prominent archaeologists working in areas outside western Europe to present the most recent evidence for the origins of the early Upper Paleolithic and its relationship to the origin of modern humans. With a wealth of primary data from archaeological sites that have never before been published and discussions of materials from difficult-to-find sources, the collection urges readers to reconsider the origins of modern human behavior.

Archaeological evidence continues to play a critical role in debates over the origins of anatomically modern humans. The appearance of novel Upper Paleolithic technologies, new patterns of land use, expanded social networks, and the emergence of complex forms of symbolic communication point to a behavioral revolution beginning around 45,000 years ago. Until recently, most of the evidence for this revolution derived from western European archaeological contexts that suggested an abrupt replacement of Mousterian Middle Paleolithic with Aurignacian Upper Paleolithic adaptations. In the absence of fossil association, the behavioral transition was thought to reflect the biological replacement of archaic hominid populations by intrusive modern humans.

The contributors, both of whom are Assistant Professors in Archaeology, present new archaeological evidence that tells a very different story: the Middle-Upper Paleolithic transitions in areas as diverse as the Levant, eastern-central Europe, and central and eastern Asia are characterized both by substantial behavioral continuity over the period 45,000-25,000 years ago and a mosaic-like pattern of shifting adaptations. Together these essays will enliven and enrich the discussion of the shift from archaic to modern behavioral adaptations.

Brodhead, R.H. (2004). *The good of this place: Values and challenges in college education*. New Haven, CT: Yale University Press. ISBN: 0-300-10600-9, $25.00.

Richard H. Brodhead, the popular Dean of Yale College from 1993 to 2004, was involved in every aspect of undergraduate education – curriculum, faculty appointments, and student life – and occupied a unique position from which to ponder the ways that college can prepare young people to live fulfilling lives.

As Dean Brodhead prepares to leave his position at Yale as Professor of English and American Studies and Dean of the College to begin a new chapter of his life as president of Duke University, Yale University Press is pleased to publish The Good of this Place: Values and Challenges in College Education. This eloquent collection of essays and speeches by Dean Brodhead addresses issues of importance to institutions of higher learning and to those who participate in them.

One of Dean Brodhead's responsibilities at Yale was to welcome new students at the annual Freshman Assembly, and this book presents his engaging remarks as he simultaneously reassured and challenged them. The later sections of the book range through various concerns of the contemporary university, from free speech and diversity issues to sexual harassment policy, residential education, the assessment of academic programs, and the complex and competing goals of college admissions.

At once reflective, witty, and wise, this book speaks to students and educators alike, to all who hope to become – or shape others to become – thoughtful and constructive members of society.

Butz, W.P., Kelly, T.K., Adamson, D.M., Bloom, G.A., Fossum, D. & Gross, M.E. (2004). *Will the scientific and technology workforce meet the requirement of the federal government?* Arlington, VA: RAND Science and Technology. ISBN: 0-8330-3529-0, $20.00.

The size and adequacy of the federal workforce for carrying out scientific, technical, engineering and mathematics (STEM) activities are ongoing concerns in many policy circles. Experts both inside and outside of government have voiced fears that this workforce is aging and may soon face a dwindling labor pool, a problem that could be compounded by skill shortages in key areas and growing numbers of non-US citizens obtaining STEM degrees in the United States. The authors asses the condition of this workforce, based on the best available data, while focusing on three main areas: trends in the US STEM workforce overall that might affect the federal STEM workforce, workforce-shaping activities in the federal STEM workforce, and legislative and programmatic mechanisms for influencing that workforce.