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Colophon

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From the Editor

Anomalies, Anachronisms, and Beliefs

From the time I was about six years old, I fell in love with *Popular Science Magazine*. My mother used this to her advantage, as it became part of her reward system for my good behavior. In fact, I had every issue dating from 1946 until the smell of that old paper and their sheer weight caused me to part with them in the 70s. Even now, when I see the front covers of those old magazines at vendors' displays in shopping malls or on the Web, they conjure up memories of my excitement about the future – that was the intrigue of that magazine for me: excitement about the future in the "world of science."

From when I was about six years old, when someone would ask me what I was going to be when I grew up, I almost always replied that I wanted to be a scientist. I had no idea what I was really saying; I just wanted to be involved in what I saw between the covers of *Popular Science*. My illusion of the nature of science continued well into high school. Though I value and appreciate my elementary and secondary education in parochial schools, the experience was almost devoid of science until I took chemistry and physics my last two years in high school. As is unfortunately still true in a number of schools today, the laboratory aspect of those two courses was almost non-existent. Yet, when I went to college and majored in general science along with industrial arts, I discovered that I was really not at a disadvantage relative to my peers who had a solid, laboratory-based, science experience in their secondary school years. I still reflect on why I was not disadvantaged and the implications that it has for both science education and technology education. Of course, the most plausible explanation is that I was never tested on *doing* science, only on how well I could perform on paper and pencil tests. We have seen what the current emphasis on this sort of testing has done in narrowing educational opportunity and removing motivation.

I cannot help but think that if *Popular Science* had been called *Popular Technology*, as it should have been in my opinion, then my career investigations would have been more logical as well as efficient. I often think the same thing when I see all the technology that is aired on *The Science Channel*. Roger Bybee, Executive Director of the prestigious and long-standing Biological Sciences Curriculum Study, and keynote speaker at one of the general sessions at the recent ITEA Conference in Baltimore, elicited a smile from me as I am sure he did from others when he mentioned the term "rocket scientist" and the clichés that have developed from it. He stated that it is a misnomer since most of what people do who work with rockets is technology, not science. "I am not a rocket technologist, but…"

Bybee's words about what is science and what is not were encouraging, especially considering his outstanding record of contributions to both science and technology, particularly in the area of curriculum. At the same time, though, it is disconcerting – a better word might be discouraging – to observe how many others at the Conference in key positions in government, business, and industry related to technology still do not realize who we are, what our purposes are, and how we can uniquely contribute. Then a part of my brain, with tongue in cheek, caused me to think of this as an advantage: that we could be whatever we want to be relative to the constituency with whom we happen to be working. I have been down this path before, but this time the roles are reversed a bit. We can change to meet whatever purpose or intent that others see for us. We are adaptable, like a screwdriver can be used to pry, and we are flexible, like the discovery that Avon's Skin-So-Soft not only moisturizes the skin but keeps the mosquitoes away as well.

Coincidentally, when I arrived home from the Conference, I read an account in our little community newspaper that featured a science fair entry of a fourth grade student. The topic of his science investigation was "What brand of fishing line will hold the most weight?" This set me aback for two reasons. One was because of the fact that I felt his investigation was clearly technology and not science, reaffirming what Bybee had said. The second was because I was teaching a course in industrial materials testing on an individualized basis to a college senior. The final project he proposed was to "Determine the strength of various types of fishing line under various loading conditions." While there is some irony in this, both the elementary student and the college student were deeply interested in the outcome of their work and were highly motivated to engage in the necessary research because they both involved *doing*. The rhetorical question is, were these projects science, technology, or engineering?

Speaking of engineering, I left the Baltimore conference realizing that engineering is clearly the predominate theme in technology education right now and integrating engineering principles is clearly the initiative in which the field is now engaged. It is no wonder, since the National Science Foundation has been promoting education about engineering at the secondary level for several years, engineering groups have taken an interest in promoting engineering-related careers at the K-12 level, competitive events for students have been developed by engineers that fit well into technology education curricula, engineers played a significant role in the development of our curriculum standards, and the government has been emphasizing engineering-related careers to bolster the economy. Moreover, some technology education teacher educators now have joint or "honorary" appointments in engineering at their respective institutions.

Acceptance of engineering by our profession ranges from, "engineering is not what we are about" to "let's change our name to 'engineering education.'" The engineering concepts taught and experiences provided in the schools range from engineering-like activities in which students sort of randomly "fall into" learning the underlying concepts, without the teachers necessarily knowing what concepts into which they were tripping their students, to actual preparation for careers in engineering and related fields, with college level course credit given to those high school students who are successful in meeting the requirements of the program. In between these two extremes, though, are some awesome programs that get students excited about what they are learning first, and then use this excitement to motivate them to learn and understand the underlying mathematics and science principles. It is illogical to think that engineering is not a part of technology and technology education. Jerry Streichler mentioned this at the Conference in his last speech as Executive Director of the Epsilon Pi Tau Honorary, reminding us that technology includes far more than just engineering.

Personally, I have always thought that engineering is something that an engineer does, just as I have thought that accounting is what an accountant does, and dentistry is what a dentist does. Occasionally I have used engineering in a casual way, such as "engineering a solution" to a problem like stringing a garden hose so that it does not damage adjacent flowers, just as I might tell a student who has an injury that I will "doctor" it up by putting a bandage on it. By and large, though, engineering in my mind denotes a career. Foster (2005) wrote an excellent treatise on this subject, making a distinction between engineering as a career versus engineering as a process.

One of the preeminent notions that started in high school for me and continues to pervade my psyche today is the value of a sound general education and technology education's role in it. I can say with fair certainty that the majority of teachers I helped prepare at the five institutions at which I have worked over the course of my career shared these general education beliefs with me. I drew deep lines in the wet concrete of my young mind between general and vocational education in those early years of preparing for my career as a teacher. As my experience accumulated, that line in the concrete began to wear away, the wear accelerating when I realized that the ultimate purpose of an educational experience is whatever the student ends up making of it rather than what we plan it to be. For the eighth grader to whom I taught woodworking in 1970 who later became a skilled woodworker, the experience was vocational. About that same time I surveyed 40 of my former students enrolled in a high school vocational automobile mechanics program and found that 82% had no intention of making automobile mechanics their career. They were there for general education purposes. Nonetheless, I remained steadfast in the *intent* of the educational programs I was delivering. That is, they were to be, foremost, good general education experiences for all, not just for boys and not just for those bound for careers in industry and technology. That was my ideal and it remains true today. I also felt convinced that this was the ideal of my profession as well.

Over the course of my career I have struggled to deal with anomalies between what I perceived as the ideals of our profession and the practice I observed, attempting to fit them in their proper place in my cognitive structure. The first major anomaly occurred upon receiving my baccalaureate degree and realized that, though I learned a lot and enjoyed my studies tremendously, I felt that I really knew little more about *industry*, than when I started the program. Addressing this anomaly became nearly a career long quest.

"Drafting" is another anomaly that has continued for at least 40 years. Every so often the drafting issue raises its head. It generally starts with the question of, "So just what is the difference between drafting in a technology education program and drafting in a vocational program?" The person continues, noting that the same textbook and equipment are used in both programs. The modern version is the fact that the same CAD software and textbooks are used in both technology education and vocational education. In either situation, I have consistently lost the argument, due to insufficient evidence, that the difference is in the *intent* of the program: one is for general education purposes and the other is to prepare people for careers in drafting. The real difference is often reduced down to the greater instructional time spent in the vocational version – and, what the student ultimately ended up doing with the experience. Where both programs go awry, though, is when the teacher gets so caught up in all the capabilities and nuances of the software that the students never have a chance to apply what they learned in an authentic problem solving context.

So why does this anomaly occur? There are several possible explanations. One is that there is not a textbook that addresses a technical area like CAD from a technological literacy perspective; our profession is too small, as well, to allow publishers to address our unique needs. Secondly, there is probably a logical sequence of learning experiences to teach fundamental concepts, concepts that one needs to master regardless of the intent of the course. The third reason could well be the real *raison d'être*. When a student ends up being employed right out of a technology education drafting program, it is indeed a significant event: accolades come from the administration and the teacher can use it as a recruiting tool for prospective students. Even though job placement was not the intent, when it happens it is rewarding and celebratory.

I often try to draw parallels in my mind between technology education and the core subjects in the school, forgetting that they are required experiences for the most part and we are not. One of the reasons for the anomaly between our ideals and practice is determined by "market share" – our share being the number of students we can attract to enroll in our courses. Leaders in our profession have tried to move away from material-based courses like woodworking for decades. Such courses exist as long as they can attract an adequate market share, regardless of whether or not they are consistent with the ideals of the profession. Now such courses no longer attract students like they used to and teachers are struggling to reorient their programs. A related anomaly is the fact that students aspiring to become technology education teachers cannot afford to take but a few, if any, high school courses in technology and still remain competitive in meeting college entrance requirements. Is it possible for a student seeking college admission to take too many mathematics and science courses?

Drafting, on the other hand, is a different sort of anomaly. When the profession moved away from material and occupational specific courses toward conceptual organizers, I watched with interest how it was all going to play out.

The idea of teaching a broad-based, conceptual course in communication as opposed to drafting/CAD, has really never caught on. In my opinion, this is related to market share: the teachers feared that if they moved away from an almost exclusive, albeit specific, emphasis on drafting and CAD, that they would lose market share. These fears were probably justified and still are, since many of the students enrolled in the drafting/CAD courses aspire for careers in engineering and architecture – or they have vocational intents to become drafters/CAD operators upon graduation from high school and could not afford the class time to enroll in a bona fide vocational program and still meet the requirements to graduate. The ideals of a broad-based communication course simply did not meet the realities of the market.

As I have written between these covers before, our connections to engineering offer wonderful opportunities for us and the students we serve. There is, however, cognitive dissonance for me when the definitive purpose of a particular program is to specifically prepare students for a career in engineering or engineering technology, especially when such preparation begins at the ninth or tenth grade level – an age range at which research has consistently shown that students have a very low career maturity. I cannot fit such preparation into our ideals of developing the technological *literacy* of those we serve or our general education purposes. I am not saying it is necessarily wrong, but it is an anomaly to the expressed ideals of our profession.

So, when we cut all the political chaff away, what do we really believe? What do we feel is good, and right, and just, and beautiful for our profession – and ourselves? We need to continue to examine our personal beliefs and reflect on the extent to which there is consistency among them, the ideals of our profession, and our actual practice. I am convinced more than ever that our profession would be much more powerful and would have much greater integrity if we all were more engaged with one another through our professional associations. If even half the technology education teachers in the US, for example, were participative members of ITEA, we would be in a much better position to withstand and react to the winds that continue to buffet us and to decide which bandwagons on which we really should be jumping. More importantly, we could take control of our profession and move it forward based on what we, collectively, believe. Adapting the words of George Sheehan (2006), the physician and author, "Success means having the courage, the determination, and the will to become the person and the profession you believe were meant to be." We need to believe in the value of what we do, and we need to do that in which we believe.

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References

Foster, P. N. (2005). Engineering: Noun or verb? *Tech Directions*, *65*(3), 19-20.

George Sheehan Quotes, (n.d.). Retrieved June 1, 2006 from http://www.brainyquote.com/quotes/authors/g/george_sheehan.html

Articles

Investigating the Relationship between High School Technology Education and Test Scores for Algebra 1 and Geometry

Richard R. Dyer, Philip A. Reed, and Robert Q. Berry

The national report *A Nation at Risk* (National Commission on Excellence in Education, 1983) sparked the standards based education reform movement in the United States. As a result of *A Nation at Risk,* the focus of education policy has shifted from school inputs to student outcomes, and from minimum competency to high proficiency standards (Lee &Wong, 2004). Accountability has become the focal point of these policy shifts. Many states have developed academic standards for students and relied on high stakes testing to measure and improve the quality of public education. The focus on accountability can be seen in the reauthorization of the Elementary and Secondary Education Act 2001, also known as No Child Left Behind (NCLB). NCLB places major emphasis on improving students' achievement in the core academic areas of mathematics, science, language arts, and social studies, by demanding that all students make adequate yearly progress (AYP).

The emphasis on improving student achievement in the core academic areas has led technology educators to show linkages between their courses and the core academic areas. Technology education provides a contextual basis for reinforcing the content of the core academic areas (Berry & Ritz, 2004). One of the programmatic goals of technology education is applying other school subjects (ITEA, 1985). For example, the project method that is frequently used in technology education often requires reading, writing, research on the history of a technological area, scientific observation, and mathematical procedures.

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Background and Purpose

Contextual Learning

Students must be able to apply learning in novel situations, but "if students are expected to apply ideas in novel situations, then they must practice applying them in novel situations" (American Association for the Advancement of Science, 1990, p. 199). We can teach skills such as measuring but if students do not know when to use a certain type of measurement, then the learning is not meaningful (American Association for the Advancement of Science, 1993) An unintended consequence of the standards movement is that a great deal of instruction has moved away from situating learning in a contextual manner. Consequently, this leads to fragmentation in which students learn bits and pieces of knowledge with little or no connection to the "big picture" (Merrill, 2001).

The predominant view of learning today posits that "people construct new knowledge and understandings based on what they already know and believe" (Bransford, Brown, and Cocking, 1999, p. 10). This philosophy, known as constructivism, is based on the foundations laid by John Dewey, Jean Piaget, Lev Vygotsky, and other educators. Constructivist teachers actively engage the student in a variety of ways. In fact, national research on recognized mathematics and science teachers show that they utilize five strategies:

- Relating – learning in the context of one's life experiences or preexisting knowledge;
- Experiencing – learning by doing, or through exploration, discovery, and invention;
- Applying – learning by putting the concepts to use;
- Cooperating – learning in the context of sharing, responding, and communicating with other learners; and
- Transferring – using knowledge in a new context or novel situation—one that has not been covered in class (Crawford, 2001, p. iii).

The Center for Occupation Research and Development (CORD) has identified these five strategies as contextual learning strategies because they help teachers put teaching and learning into context. CORD has developed a series of resources on contextual learning that are research-based and include excellent classroom lessons (see Center for Occupation Research and Development, 1999a and 1999b). Transfer of learning is the central concept upon which these materials are based and the ultimate goal of contextual learning. Transfer of learning is the application of skills and knowledge learned in one context being applied in another context (Cormier & Hagman, 1987). If the skills to be transferred can be identified and the contexts can be established where learners see that the skills they have learned can be applied to solve problems in other contexts (situations), then student success should improve (Bjork & Richardson-Klavhen, 1989).

Effects of Integrated Curriculum

Curriculum integration of technology education with the core academic areas, particularly mathematics and science is not new to technology education (see LaPorte & Sanders, 1993; Childress, 1996). However, standards-based integration and the call for supporting research have been gaining attention in recent years (National Research Council, 2002; Harris and Wilson, 2003). Such integration can provide learning opportunities for students that are relevant and meaningful (Loepp, 1999). Beane (1996) listed four broad dimensions to curriculum integration: (1) the curriculum is organized around the real world; (2) pertinent knowledge is organized without regard to subject area lines; (3) learning is not based on an eventual test, but rather the content; and (4) real application and problem solving are used to connect the content to real world application. While the interest on curriculum integration has increased, there is a dearth of research on the impact that technology education has on student achievement in the core content areas.

Satchwell and Loepp (2002) designed and implemented a curriculum for technology education that integrated mathematics and science. They compared students involved in their curriculum project with students not involved and found a positive effect on mathematics and science achievement using a sub-test adopted from the Trends in International Mathematics and Science Study (TIMSS). Merrill (2001), however, found no differences between students taught using an integrative curriculum (technology education, mathematics, science) and those taught using traditional curricula.

Burghardt and Hacker (2002) focused on teachers using an integrated curriculum. They found that fourth grade students who had teachers trained with the integrated curriculum outperformed students who had teachers who were not trained on the New York State's Elementary School Science Program Evaluation Test. In addition, these students achieved significantly above the State average on the mathematics test.

Context for the Study

Almost every state has adopted academic standards in core academic areas. In addition, many states have developed assessment instruments aligned to their standards, to measure whether students have learned what was described in the standards. The Commonwealth of Virginia adopted the Standards of Learning (SOL) for the four core academic areas: English/Language Arts, Science, Mathematics, and Social Studies/History. The SOLs are important because they establish targets and expectations for what teachers need to teach and students need to learn. The SOL requirements provide greater accountability on the part of the public schools and give the local school boards the autonomy and flexibility they need to offer programs that best meet the educational needs of students (Virginia Department of Education, 1995).

In Virginia, the career and technical education (CTE) teachers have been utilizing competency based education (CBE) as a set of standards for teaching and learning. In 2000, the Virginia Department of Education's (VDOE)

Career and Technology Education Service developed crosswalks (correlations) to the SOLs in the four core content areas. These crosswalks provided integrative and contextual connections between CTE and the four core academic areas. These crosswalks became part of the competencies and an important tool to encourage communities to support the academic programs. After the development of the crosswalks, the VDOE developed a website, Virginia Linkages (http://www.valinkages.net/), to show explicit connection between the SOLs in the four core academic areas with courses in CTE areas (Virginia Department of Education, n.d.). A lesson plan template is provided as well as lesson bank. With this tool, teachers can plan learning opportunities that integrate CTE with the four core academic areas, apply a contextual basis to the SOLs, and plan meaningful opportunities that show application and relevancy to students.

Data on students taking CTE courses and performance in the four content areas indicate an increase in secondary students taking CTE courses and an increase in the pass rate percentage from the 2000-2001 academic year to the 2002-2003 academic year (Virginia Department of Education, 2000, 2001, 2002, & 2003). Table 1 shows the percentage of secondary students enrolled in CTE courses in Virginia who passed the SOL End-of-Course Tests in the four core areas from the 2000-2001 academic year to the 2002-2003 academic year. The data in Table 1 are not aggregated by CTE courses or courses within the four core academic areas. More detail is necessary to see relationships between

Table 1
Percentage of CTE students who passed the SOL End-of-Course Tests and total number of students enrolled in CTE courses (Virginia Department of Education, 2000, 2001, 2002, & 2003)

Core Academic Area	**Academic Year**			
	2000-2001	**2001-2002**	**2002-2003**	**2003-2004**
English				
%	75.2	78.0	86.3	81.5
n	71,182	74,666	73,011	79,860
Mathematics				
%	61.1	64.5	67.5	70.6
n	77,897	82,205	84,114	93,057
History				
%	54.7	69.7	71.7	73.8
n	87,708	92,938	91,987	103,505
Science				
%	69.8	69.8	70.4	70.3
n	82,823	85,922	84,329	95,19

students' performance on the SOL End-of-Course Tests and course taking patterns. If it were determined that technology education data are consistent with existing CTE data, then it is plausible that such data would show a significant positive relationship between enrollment in technology education and performance on SOL End-of Course Tests. While connections do not suggest cause and effect relationships, significant positive findings may suggest that an investigation into a cause and effect relationship between enrollment in technology education and performance on the SOLs may be informative.

Purpose

The purpose of this study was to compare the SOL End-of-Course mathematics performance of high school students who completed courses in illustration and design technology to students who have not completed an illustration and design technology course. This technology education course is an elective that fits under the CTE umbrella in Virginia. The following research questions were developed for this study:

1. Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses?
2. Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course?

Methodology

The population for this study was composed of students in the 10th, 11th and 12th grades who had taken the Algebra I and/or the Geometry end-of-course SOL examinations during the 2002-2003 school year. These students attended an urban high school in the southeastern region of the United States. There were 996 students matching the population criteria. They were separated into two groups for this study. The first group of students had taken one or more of the following Illustration and Design courses: Technical Drawing, Engineering Drawing, and Architectural Drawing. There were a total of 89 students in this group. All 89 students had taken Technical Drawing, with 39 having also taken Engineering Drawing, and 17 having taken Architectural Drawing during the time frame of the study. There were 907 students in the second group. These students had not taken any Illustration and Design Technology courses.

Data Collection

After obtaining necessary approval, data were collected from the high school's information database to generate a report of students who took the Algebra I and Geometry SOL tests during the 2002-2003 school year. In addition, technical illustration and design attendance data were collected for the same time period (Dyer, 2004). The following criteria guided the selection of students:

1. Students identified as special education were omitted from the study since test scores for these students are not listed within the database.
2. Students who took the Algebra I and Geometry End-of-Grade tests during the 2002-2003 academic year were divided into two groups to answer the first research question: one group of IDT students and one group of non-IDT students.
3. To test the second research question, students who retested in Algebra I and Geometry for the 2002-2003 academic year and who had taken Illustration and Design Technology courses between their first test and the retest were selected for the Illustration and Design Technology group. Students not taking an Illustration and Design Technology course between their first test and retest were selected for the non-Illustration and Design Technology group.

Students' names were used only during the database query and sorting process and compared to attendance records to identify the students for the Illustration and Design Technology group. After sorting was completed, names were removed and all retained data were placed in one of two categories: Non-Illustration and Design Technology or Illustration and Design Technology.

Statistical Analysis

A *t* test: was used to validate the first research question: Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses? The SOL scores of the Non-Illustration and Design Technology and Illustration and Design Technology groups were used to determine if there was a significant difference in the scores between the two groups. A Chi-square test was used to validate the second research question: Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course? The number of retests that the Non-Illustration and Design Technology and Illustration and Design Technology groups took was used to determine if there was a significant difference in the number of times the test was taken between the two groups. The means and standard deviations were used to show the quality of testing between the Non-Illustration and Design Technology and Illustration and Design Technology test groups.

Findings

Table 2 shows the composition of the two groups and their pass/fail ratio. The Illustration and Design Technology group had a 78% passing rate, while the Non-Illustration and Design Technology group had a passing rate of 73%. Table 2 also shows the means and standard deviations of test scores for the two groups. The Illustration and Design Technology group scoring on average 14 points higher than the Non-Illustration and Design Technology group.

Table 2
Composition of the Non-Illustration and Design Technology and Illustration and Design Technology Groups

Groups	Total	Pass	Failed	Mean	*SD*
Non-IDT	907	661 (73%)	246 (27%)	427	49.34
IDT	89	69 (78%)	20 (22%)	441	45.32

The *t* test analysis was used to test the first research question: Did students who had taken illustration and design technology courses perform better on their mathematics SOL tests than students who did not take illustration and design technology courses? The *t* test value for this study was 2.65 and the value was significant at the $p < .01$ level. This finding indicates a significant difference between the SOL end-of-course test scores of students who took Illustration and Design Technology courses and those that did not.

The Chi-square test was used to answer the second research question: Did students who had not passed the mathematics SOL tests do better on their retake examinations after they took an illustration and design course? Students who retested in Algebra I and Geometry for the 2002-2003 academic year but had taken Illustration and Design Technology courses between their first test and the retest were selected for the Illustration and Design Technology group. Likewise, students not taking an Illustration and Design Technology course between their first test and retest were selected for the non-Illustration and Design Technology group. There were 18 students within the Illustration and Design Technology study group requiring a retake examination from the previous school year(s). All 18 of the students took an Illustration and Design Technology course prior to passing the retake exam. The Non-Illustration and Design Technology group had 410 students requiring a retake examination from previous test cycles; 360 passed the retake exams. Table 3 shows the analysis of the retake examinations for each group. The calculated X^2 value was 2.492, the value from the table of significance at the $p <.05$ was 3.84. There was not a significant difference between students taking Illustration and Design Technology courses and a student's ability to pass retake examination.

Table 3
Number of Algebra 1 or Geometry test retakes for the Non-Illustration and Design Technology and Illustration and Design Technology students

		Number Passing After Retake		
Groups	**Total**	**One Retake**	**Two Retakes**	**Failed**
Non-IDT	410	251	109	50
IDT	18	18	0	0

Conclusions and Recommendations

The standards-based reform movement that began in the 1980's has evolved. In the 1990s, the focus was on producing subject-area content standards and modifying instruction. Today, the focus has shifted to assessment and, for technology education, demonstrating the impact on children and the efficacy of the discipline within general education. A compelling description of this need and a research agenda is outlined in the publication *Investigating the influence of standards: A framework for research in mathematics, science, and technology education* (National Research Council, 2002).

The results of this study help meet the call for meaningful research in several ways. This study outlined a method of data collection that can be easily replicated. Data were selected from test records in an existing school system database and from instructor attendance records. Both sources are readily available in most school systems, thus eliminating the need for researchers to create a research design and data collection method from scratch. Not only will this method of research save time, but also add credibility by using accepted data sources. Research problems can be eliminated such as the development and validation of instruments and human subject issues such as confidentiality.

Additionally, the types of courses offered in Virginia's Illustration and Design program (Technical Drawing & Design, Engineering Drawing & Design, and Architectural Drawing & Design) are widely offered in secondary schools within the United States. According to a national study of secondary technology education by Sanders (1999), Drafting/CAD was the second most often taught course and Architectural Drawing/Architectural Drafting was the fifth most popular course. Because these courses are offered so widely, this type of study could be used to collect data at the local, regional, and national levels. This form of large-scale data collection is especially important since the United States does not have a national education system.

Nevertheless, it must be noted that college-bound students tend to enroll in technology education drafting and CAD courses. They may be inherently higher achievers than the general school population. In order to determine whether or not there is a relationship between *instruction* in technology education and improved achievement in academic subjects, more studies must be conducted that are designed to determine if such relationships exist.

The conclusions of this study have several implications for practice. The fact that students in the sample that initially took IDT courses had a significantly higher pass rate on their mathematics tests is particularly noteworthy. It is plausible that the IDT courses helped this sample of students with their mathematics tests; however, IDT students who did not initially pass their examinations did not have a significant pass rate on their retake tests. However, all eighteen students did pass after one retake. There appears to be a trend showing that the IDT course may help students pass the test on re-takes, even though it did not reach statistical significance. The researchers recommend that this study be replicated with a larger sample in order to include more students.

In classroom practice, perhaps there is a need for technology instructors to help with the remediation of students who do not pass the test initially. For example, when students do not pass an SOL test in Virginia, tutors are often provided for the subject area (i.e. Algebra I). The argument could be made that mathematic instructors and tutors should work with technology teachers to help students understand the relevance and application of certain mathematic skills.

Finally, technology educators at the primary, secondary, administrative, and teacher education levels all need to insure that contextual learning is truly taking place. The profession has been working for five years to implement the *Standards for technological literacy: Content for the study of technology* (ITEA, 2000) and many states like Virginia have developed "crosswalks" to academic standards. As a profession we must insure our planning at all levels implements contextual practice *and* includes meaningful assessment. The profession's long tradition of contextual practice is meaningless if it cannot delineate the impact it is having on students.

References

American Association for the Advancement of Science. (1990). *Science for all Americans: Project 2061*. New York: Oxford University Press.

American Association for the Advancement of Science. (1993). *Benchmarks for science literacy: Project 2061*. New York: Oxford University Press.

Beane, J. (1996). On the shoulders of giants! The case for curriculum integration. *Middle School Journal, 28*(1). 6-11.

Berry, R. Q. & Ritz, J. M. (2004). Technology education - A resource for teaching mathematics. *The Technology Teacher, 63*(8),-20-24.

Bjork, R.A. & Richardson-Klavhen, A.(1989). On the puzzling relationship between environmental context and human memory. In C. Izana (Ed.) *Current Issues in Cognitive Processes: The Tulane Floweree Symposium on Cognition* (pp. 313-344). Hillsdale, NJ: Erlbaum.

Bransford, J. D., Brown, A. L., and Cocking, R. R. (Eds). (1999). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academy Press.

Burghardt, M. D. & Hacker, M. (2002). Large-scale teacher enhancement projects focusing on technology education. *Journal of Industrial Teacher Education, 39*(3). 88-103.

Childress, V. W. (1996). Does integrating technology, science, and mathematics improve technological problem solving? A quasi-experiment. *Journal of Technology Education, 8*(1), 16-26.

Center for Occupation Research and Development. (1999a). *Teaching mathematics contextually*. Retrieved April 8, 2004, from http://www.cord.org/lev2.cfm/87

Center for Occupation Research and Development. (1999b). *Teaching science contextually*. Retrieved April 8, 2004, from http://www.cord.org/lev2.cfm/87

Cormier, S. & Hagman, J. (1987). *Transfer of learning*. San Diego, CA: Academic Press.

Crawford, Michael L. (2001). *Teaching contextually: Research, rationale, and techniques for improving student motivation and achievement in mathematics and science*. Waco, TX: CCI Publishing, Inc.

Dyer, R. R. (2004). *The relationship of high school mathematics standard test scores and illustration and design technology courses*. Unpublished graduate research paper. Norfolk, VA: Department of Occupational and Technical Studies, Old Dominion University.

Harris, M. and Wilson, V. (2003). *Designs on the curriculum? A review of the literature on the impact of Design and Technology in schools in England*. Retrieved September 29, 2005 from http://www.dfes.gov.uk/rsgateway/DB/RRP/u013797/index.shtml

International Technology Education Association. (1985). *Technology education: A perspective on implementation.* Reston, VA: Author.

LaPorte, J. and Sanders, M. (1993). Integrating technology, science, and mathematics in the middle school. *The Technology Teacher, 52(*6), 17-21.

Lee, J. & Wong, K. K. (2004). The impact of accountability on racial and socioeconomic equity: Considering both school resources and achievement outcomes. *American Educational Research Journal, 41*(4), 797-832.

Loepp, F. L. (1999). Models of curriculum integration. *The Journal of Technology Studies, 25*(2), 21-25.

Merrill, C. (2001). Integrated technology, mathematics, and science education: A quasi-experiment. *Journal of Industrial Teacher Education, 38*(3), 45-61.

National Commission on Excellence in Education. (1983). *A Nation at risk: The imperative for educational reform*. Washington, DC: United States Department of Education.

National Research Council. (2002). *Investigating the influence of standards: A framework for research in mathematics, science, and technology education*. Committee on understanding the influence of standards in K-12 Science, Mathematics, and Technology Education. Washington, DC: National Academy Press.

Sanders, M. E. (1999). New paradigm or old wine? The status of technology education practice within the United States. *Journal of Technology Education, 12*(2). 35-55.

Satchwell, R. E. & Loepp, F. L. (2002). Designing and implementing an integrated mathematics, science, and technology curriculum for the middle school. *Journal of Industrial Teacher Education, 39*(3). 41-66.

Virginia Department of Education. (2003). Career and technical education statewide annual performance report. Retrieved June 9, 2005, from http://www.pen.k12.va.us/VDOE/Instruction/CTE/cters/2003apr/aprssr.pdf

Virginia Department of Education. (2002). Career and technical education statewide annual performance report. Retrieved June 9, 2005, from http://www.pen.k12.va.us/VDOE/Instruction/CTE/cters/2002apr/aprssr.pdf

Virginia Department of Education. (2001). Career and technical education statewide annual performance report. Retrieved June 9, 2005, from http://www.pen.k12.va.us/VDOE/Instruction/CTE/cters/2001apr/aprssr.pdf

Virginia Department of Education. (2000). Career and technical education statewide annual performance report. Retrieved June 9, 2005, from http://www.pen.k12.va.us/VDOE/Instruction/CTE/cters/2000apr/aprssr.pdf

Virginia Department of Education. (1995). Standards of learning for Virginia public schools. Retrieved June 9, 2005 from http://www.pen.k12.va.us/VDOE/Superintendent/Sols/

Virginia Department of Education. (n.d.). Virginia Linkages. Retrieved June 9, 2005, from http://www.valinkages.net/

Productivism and the Product Paradigm in Technological Education

Leo Elshof

"To keep every cog and wheel is the first precaution of intelligent tinkering"
–American ecologist Aldo Leopold (1993)

Aldo Leopold was a pioneer in United States' wildlife management and his axiom is certainly familiar to anyone who has tried to repair a complex technological system, it applies equally whether one is rebuilding a small block V8 engine or repairing a computer. "Keep all the pieces" is good advice because in all likelihood they will all be necessary to restore the proper functioning of the system. Before we begin tinkering it's a good idea to figure out the purpose of the components so even if we initially forget where the pieces go, we will (if we're competent) eventually figure out where they fit. The metaphor is appropriate in light of the impact our technological systems of production and consumption are having on the biosphere. We are effectively tinkering on a dangerous planetary scale, damaging, even destroying critical pieces of the biosphere, often without even comprehending the role of the systems we have lost in maintaining a thriving and healthy planet. There is a serious disjunction between our science-informed environmental knowing and our technological-economic actions.

This paper will explore the nature of the modern product with respect to its relationship to technological education. The term *"product paradigm"* refers to a number of interrelated, implicit and explicit beliefs and assumptions regarding the nature of postmodern technological product culture that are increasingly problematic for technological education. It will also offer ideas to move technological education away from the *product paradigm*. In general the *product paradigm* consists of four distinct assertions. We will explore each of these nonexclusive dimensions in turn, but first we need to examine the critical role design has to play in perpetuating the *product paradigm*.

The Nature of the Problem

The ability to design, develop, manufacture, use, choose, and maintain technological products are an important part of technological education

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(International Technology Education Association, 2000). It is also important that students develop the confidence and familiarity that will prepare them to "deal intelligently with current and future technological products" on their own (ITEA, 2000, p.6). Life as we know it would be virtually inconceivable without the plethora of products which define our built environment. Consumer-citizens situated within this context find it increasingly difficult to imagine ecological alternatives to the current product-inspired reality, thus making it more difficult to unravel the ecologically problematic dimensions of it. Technology fundamentally involves applying knowledge, materials, resources, tools, and information in designing and producing products or artifacts, structures and systems (Stein, Docherty, Hannam, 2003). Technological design activities should engage students in moral and ethical judgments that reach beyond the question of whether a product can be manufactured, to ask if it ought to be (Conway, 2000, p.250). As Flowers (1998) points out few products are designed to meet actual needs, instead human wants are engineered to meet product availability, thus reinforcing the message of materialism: "They are taught that creatively designing products is a good thing, regardless of the outcomes. The ultimate criterion for success is money" (p. 21). Because students come to technological design with preexisting notions and concepts about the design process (Jones, 1997), it is crucial that technological education provide opportunities for them to critically examine the implications of product materialism and more environmentally responsible alternatives.

Product design activities can provide opportunities for reshaping students' values and calling "new ones into play" (McLaren, 1997, p. 261). Thus product design should be closely connected with identifying and reconciling technical, economic, aesthetic, social, environmental, and moral values (Layton, 1993, p.21). The product design field has moved away from a preoccupation with isolated "things" and toward an understanding of how products operate in human, environmental, and cultural systems (Buchanan, 2001). De Vries (1997) identified a number of observable design factors relevant to the development of a particular product. These included scientific, technological, market, political, juridical and aesthetic factors. To this list a crucial missing factor needs to be added and that is an "ecological factor" that speaks to the environmental performance of a product. The problems identified by Petrina (2003) concerning CAD education in classrooms and in teacher education, that identified: "over-exaggerated technical content" and "attenuated and naïve" (p. 50) discourses concerning the ethical-personal and sociopolitical content of technological education, are problematic insofar as they are often ignored.

The notion of a *product paradigm* stems from the fact that the conventional manner in which we have considered the role of products in the cultural life of rich, developed nations needs to be reassessed in light of scientific realities and in the paradigms that inform their production. The *product paradigm* draws our attention to these underrepresented considerations, it brings to the fore the need to question and reassess the manner in which we teach young people about product design, development, manufacture, use, and disposal. It is more accurate to think of products today in terms of interdependent *systems* of consumption and production. Products are marketed in terms of lifestyle systems of consumption and lifestyle image. The term *"production-consumption"* system or cycle more accurately reflects the fact that designers, engineers, producers, suppliers, distributors, advertisers, salespersons, consumers, users, waste managers, applied scientists, researchers, and regulatory agencies are involved in an ongoing process of technological autopoeisis[1] (Krippendorff, 1996, p. 173). The cycle is autopoetic insofar as all the participants in this process have a stake in maintaining and expanding it.

Human technological systems have impacted planetary carbon and nitrogen cycles (Smil, 1997), changed the pH and distribution of rainfall, and are now fundamentally altering climate across the globe (Intergovernmental Panel on Climate Change, 2001). In essence, our economies have become degenerative not regenerative with respect to our "natural capital" (Hawken et al., 1999) and the long-term health and sustainability of the ecosystems upon which we all ultimately depend. Hundreds if not thousands of peer-reviewed science studies have indicated that the health of the planet's natural systems are in precipitous decline (World Resources Institute, 2005). The rapid decline in biodiversity over the last 50 years due to human activity has been more rapid than at any time in human history. Scientists estimate that 12 percent of birds; 23 percent of mammals; 25 percent of conifers and 32 percent of amphibians are threatened with extinction, and the world's fish stocks have been reduced by 90 percent since the start of industrial fishing (World Resources Institute, 2005). The critical insight emerging from geophysical, biochemical, and biophysical Earth systems science is that no "one" solution will remedy the crisis. It's not as simple as pointing to a product or system here or there and saying that if we fix this, then things will be O.K. The global sustainability crisis is nothing less than an indictment of our technological systems in toto. Technologies that may make sense when constrained by ethics, regulation and genuine wisdom, become self destructive when through the *product paradigm* they are driven solely by "bottom-line" considerations.

The inescapable conclusion is that our systems of technological production and consumption and the economy they support are dangerously out of step with the assimilative and regenerative capacities of Earth's ecosystems. In order to make a successful transition toward environmental sustainability, the U.S. National Academy of Sciences is emphatic:

> This transition could be achieved without miraculous technologies or drastic transformation of human societies…What will be required, however, are significant advances in basic knowledge, in the social capacity and technological capabilities to utilize it, and in the political will to turn this knowledge to action (National Research Council, 1999, p. 160).

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[1] Autopoesis is the term applied to "self-producing" and self organizing systems after Maturana & Varela (1987). The term "industrial-metabolism" and the insights of biological autopoeitic systems are being used to design industrial ecologies. This is an important and neglected area within technological education.

Technological education has the potential to foster the eco-technological and social ingenuity to make this transition a reality, but first it must confront the *product paradigm*.

Factors within the Product Paradigm

The first of the four factors in the *product paradigm* states that technologies have only instrumental purposes and only instrumental meanings can be inscribed in them. Within the *product paradigm*, the symbolic dimensions of products are ignored, students are seldom asked *why* a particular technological product comes to hold the meanings it does. Without a critical cultural perspective towards technology, more products mean more cultural improvement… ad infinitum. In the *product paradigm*, products are understood to be progress embodied and construed as the driving force of cultural "progress." The nature of the *quality* of the relationships we have with our various technologies and how technologies change human relationships is for the most part left unexplored. Products are simply assumed to benefit all cultures and all groups within a given community more or less equally. The notion of technological benefits being distributed differentially is foreign. The iconic products of cultural progress in one region, large gas guzzling SUV's and enormous homes in North America for example, become harbingers of an oncoming dystopian world for people in coastal Bangladesh, the island of Tuvalu, and the Inuit in Canada's arctic. If global warming continues as the best scientific models tell us it will, these technologies will be in part responsible for rising sea levels and melting permafrost. The peoples least able to benefit from runaway product consumption, will be among the first to be hardest hit by climate change (Monbiot, 2005).

Products, apart from their functional and instrumental purposes, also serve as carriers of a worldview, a way of relating to not only our human social world, but the natural world as well. For many people the relationships they establish with or through their technologies are more immediate and "real" than any "always distant" concerns about the environmental consequences associated with their consumption. A significant cultural lag exists when it comes to understanding the ecological impacts of our production-consumption systems and acting upon that knowledge on a personal and political level. However, when it comes to adopting some technologies and practices, the term "lag" is hardly an appropriate description, Doucet asks:

> How long will this cultural lag between our methods of production and humanity's biological sustainability endure? How can we develop the same speed and success in adapting our economies to biological imperatives as we have with machines like the BlackBerry and the Ipod? (Doucet, 2005, p.3).

Technological education has an important role to play in reducing the cultural lag to the widespread adoption of renewable energy technologies, product service systems, and other more ecologically "smart" technologies. Reducing this lag will entail helping young people explore and understand how corporations have created the symbolic meanings we attach to our SUV's, our enormous homes, and the ever-shortening cycles of product consumption.

Our relationship with products is not simply utilitarian; people can develop strong and even passionate emotional ties to their products, their belongings (Norman, 2004). We increasingly use products of various forms to construct, define, and project our identities and to mediate our social relationships. In schools adolescents use a variety of technological products to identify and signal style consciousness, group membership, status, and wealth. Schools have been transformed into not only sites of consumption, but also places where consumer behavior, consumer identity, and consciousness are constructed (Schor, 2004).

How Products Work

Furby (1991) suggested that material possessions have a number of meanings that may be categorically distinguished by their instrumental or symbolic functions. We are continuously involved in the act of interpretation and meaning making involving both dimensions. As "categorical symbols," products signify positional status as well as the smaller and broader social groups to which we belong. They also serve a self-expressive function in that they are deemed to project an individual's unique attitudes, goals, and personal qualities (Furby, 1991, p. 167). In Western culture, power, wealth, and status are some of the most common symbolic attributes expressed through product technologies. Advertising today is focused on "branding" consumers that entails developing a form of brand relationship and loyalty between consumers and whatever product is being sold. In essence, the product being "manufactured" in this symbolic product relationship is the consumer (Quart, 2004).

The language of corporate business or what Lankshear terms "Fast Capitalist" (Lankshear et al.,1996) discourses derive their power from the fact that: "how we think and write about the world has a great deal to do with how we act in and, thus, what it becomes in reality" (Lankshear et al., 1997, p. 25). These discourses that are found in the business press and mainstream media use metaphors like the "friction-less economy," "brand management," "outsourcing," and "tween" markets. In the hands of managers and politicians they become the background upon which decisions are enacted in the workplace and society. Fast-capitalist discourses, in combination with cultural, economic, and political forces (and worldviews), have shaped the technological education curriculum and the subjectivities of teachers and students alike. These powerful cultural discourses are transforming the nature of what we consider a technological "product" to be and at the same time shaping a general discourse concerning the attributes of the people who are needed to create and consume these products. It is crucial to appreciate the interdependent nature of these discourses as a prerequisite to developing an alternative and critical perspective toward technological education, one which situates technology and the meanings inscribed in it as a cultural enterprise (Petrina, 1998; 2000). In order to disentangle the meanings inscribed in product forms it is important that technology is understood as object and technique situated *within* culture, and not external to us.

It is useful here to explore Csikszentmihalyi's distinction between "instrumental" and "terminal" materialism. In terminal materialism the end is valued as final, not as itself a means to further ends and therefore not subject to "cultivation." This entails ignoring the outcomes of transactions which conflict with the terminal goal – here "the end justifies the means" because the object is valued exclusively as an end in and of itself (Csikszentmihalyi et al.,1995, p. 231). The fast capitalist instrumental version of technological education fosters terminal materialism, through an emphasis on the development of objects of immediate and ephemeral iconic-marketable value, objects geared to terminal consumption. Consideration of a product's "meaning" is reduced to consideration of transient market satisfaction and creative consumer manipulation. The idea of terminal materialism is consistent with a worldview that seeks to maximize every individual's drive to consume products. Global spending on advertising will reach $604 billion in 2006 (Sanders, 2005), more than half of which is spent in U.S. markets. Overall this represents an almost nine-fold increase over 1950 (Worldwatch, 2004).

Instrumental materialism on the other hand is defined as the possession of things which serve goals that are independent of greed itself and that have a specific limited scope within a context of purposes. (Csikszentmihalyi et al.,1995, p. 231). Through instrumental materialism we cultivate the development and use of objects as instruments that are an essential means for discovering and furthering other goals. The larger context in which both processes work is the "fuller unfolding of human life" (Csikszentmihalyi et al.,1995, p. 231). Examples here might include musical instruments, books, and hiking equipment.

Likewise, productivism is a discourse that embodies a wide variety of beliefs, practices, concepts, and "sedimented structures" which include, in part, an expansionistic, growth-oriented ethic and a socio-economic orientation to life (Smith, 1998, p. 10). The discourse of productivism is part of a complex hegemonic system within which we believe: "the everyday material actuality of industrialization and the concomitant metaphysical faith in its ability to improve the quality of human life" (Smith, 1998, p. 5). Productivism as an encompassing belief system offers an uncritical valorization of industry, economic growth, and the consumption of technological products and is a theme within many parts of technological education. As Smith explains:

> Productivist discourse is a story in which scientific and technological knowledge promise a happy ending to the problems of poverty, disease, and tyranny. The affluent West holds up itself and its history as both the example and the way (Smith, 1998, p. 34).

The focus of productivism is based on the normative assumptions that technological education should exist to promote economic growth by producing the skilled "human resources" required to increase productivity and profit and to produce "skills for work" and so enhance the employability of students (Anderson, 2004; ITEA, 2000). In light of the environmental consequences described earlier, these assumptions need to be scrutinized much more critically to assess whether they do form a rational and legitimate basis for technological education.

The corporations and systems that sustain and expand hedonic consumption have become so ubiquitous that to even question this paradigm is almost akin to aligning one's self against basic "human nature." The process of "adaptation" plays an important role in human psychology and our relationship to products; we tend to get used to things and then we take them for granted (Schwartz, 2004, p. 184). Our ever-expanding list of perceived "needs" is often derived from the new "wants" we create when we compare our personal material situation to our neighbors or to those we see in the media. After we finally acquire something we have longed for, or even dreamed about, it just doesn't excite us quite as much. With time our once "precious" product may grow to be a disappointment, then it becomes trash. Schwartz terms this "hedonic adaptation" and explains in part why in 1973, 13 percent of Americans considered air-conditioning in their cars as a necessity, but today 41 percent do (Schwartz, 2004, p. 169). This rapid "fad" change in the cultural meanings of a technological product can have profound ripple effects on the natural world. History is replete with examples of animals hunted and fished to extinction to meet the ephemeral demands of the product market for their fur, flesh, and feathers.

Increasingly today, the marketing of products and lifestyle construction form a seamless cultural web. Postmodern integrated product marketing strategies weave a "seamless web" of technologies, entertainment, and consumption. Jeep "Liberty" sport utility vehicles(SUV's) are cross marketed with Columbia outdoor clothing and gear, the Disney film "Madagascar" is used to sell Dodge "Caravan" minivans, or hockey legend Wayne Gretzky becomes a spokesman to sell Ford sport-utility vehicles and McDonald's products. A typical advertisement for the Ford Explorer SUV features a man using a snow blower to blow snow *onto* his driveway. The man then opens his garage and proceeds to drive his SUV over the pile while a voiceover intones: "Whoever says you don't need a four wheel drive in Toronto, isn't having enough fun" (CBC, 2005). This ad epitomizes the hedonistic relationship we have with some of our most environmentally damaging products. While citizens of the developed world over consume, the world's poorest people will need to *increase* their consumption levels if they are to lead lives of "dignity and opportunity" (Gardner et al.,2004). Appeals to "do the right thing" based on guilt, fear, or other external pressures only have limited success. In fact, they often cause people to withdraw and ignore the issue at hand altogether. The better approach is to help young people discuss and debate the meanings that products hold for them.

The second *product paradigm* factor occurs when product production-consumption is not directly connected to resource depletion and the pollution caused by the extraction, processing, transportation, and disposal of materials in other parts of the world.

Globalization has exacerbated the product paradigm. In the rich North, we take it for granted that we can walk into a food store in nearly any month of the year and purchase fresh strawberries, mangoes, and bananas that have been air freighted in from all over the globe. The average size of North American grocery stores has “mushroomed” from 31,500 square feet in 1991 to 44,000 square feet in 2001 and stocks an amazing 30,580 items (Paquet, 2003). All of these products are transported using oil in some form and in the age of “peak oil” (Deffeyes, 2005) we are entering, will become even more unsustainable. The infrastructure to support these global product supply chains consist of massive logistical and technical networks of people, computers, and multi-modal transportation systems. Beneath the surface of these systems is often an ecological and human “wake” of pollution, degraded water, soils, and exploited workers – all effectively, and in many cases deliberately, hidden from the consciousness of the product-consumer.

If design connotes “consciousness, intention, in making, using, or acting” (Mitcham, 2001, p. 31), then it is a deficient design consciousness that is responsible in part for the proliferation of our mass produced culture of consumption. Products designed with little or no consideration given to the energy consumed and wastes produced in their manufacture and use, or the eventual fate of the constituent components and materials at the end-of-useful life are on a planetary scale, life-threatening. Bringing a new product to “life” entails a responsibility which extends beyond point of purchase and the immediate now.

The “hedonic adaptation” effect described earlier also contributes to the problem of the “rebound effect.” The rebound effect occurs when, through redesign, mass production, energy, and/or material efficiency savings, the cost of a product decreases to a point where aggregate consumption of it increases, effectively neutralizing or diminishing any eco-efficiency gains. For example, the gains achieved through more fuel efficient cars will be lost if people simply drive more because they can afford to. This environmentally counter-productive process raises important questions concerning the simple commonplace notion that greater consumption of “green products” will resolve all of our environmental problems. Unless eco-efficiency gains are coupled to genuine reductions in aggregate material and energy throughput in our economy, little environmental benefit is gained, and as Guber asserted: “the Earth does not benefit from symbolic gestures” (Guber, 2003).

Compounding the problem are simplistic and inadequate design processes that encode values that lead to increased consumption and waste, not eco-product literacy. From a political ecology and human justice standpoint, our design education processes are unsuccessful to the degree that waste has becomes a “natural” outcome of production processes and the terminal state of the constituent materials at the end of a product’s life (Petrina, 2000, p. 212). Considerations of pollution prevention, if they occur at all, happen at the “end of the pipe” so to speak, after the product and manufacturing processes have been designed. This is too late, and not as effective as integrating design for the environment (DfE) in the initial design process. Design processes that lead to dematerialization, energy efficiency, and even elimination of the need for the product via product service systems (PSS) are crucial.

Technological educators need to encourage students to critically examine the “technological wake” (Durning, 1997) of product manufacture and use and to explore the political ecology of products and product systems (Petrina et al., 2000). Although social and environmental justice issues are almost completely severed from our product consciousness, educators have a moral and ethical responsibility to help young people reconnect these issues to product design, manufacture, and use. This entails following the global wake of the product with respect to materials, energy, and waste over its entire lifetime. It is also on these global "frontiers" where the raw materials fueling global production-consumption systems are harvested and where safeguards with respect to workers' safety, human rights, social justice, and environmental harm are most precarious. As Sachs pointed out:

> Ever since the age of Pizarro, the 'New World' has been combed for valuable raw materials. But today the exploration and exploitation of new sources stretches into the remotest parts of the world's sea and land masses. Oil is extracted from deep inside the tropical forest and deep beneath the ocean waves; timber is carried from faraway Patagonia and Siberia; and floating fish factories plough the seas from the Arctic to the Antarctic. The opening of frontiers to foreign corporations has intensified the pressure to move forward the front line of exploitation. (Sachs, 2003, p. 13)

Globalized information systems provide the logistical control to interconnect far flung raw material suppliers, transportation systems, sub-assembly manufacturers, and point of sale inventory systems. These same information technologies are used by advertisers to create demand, to continually resignify the product, and to build emotional attachment and brand-logo loyalty (Schor, 2004). Where does ethical product design enter the picture when a huge proportion of the materials that enter the consumer-material cycle end up in landfills? In 1970 the average new home was 140 m^2, today the new "McMansions" in North America average 215 m^2, with much of the expanded area required to house accumulated products (McLaughlin, 2005).

The third *product paradigm* factor addresses non-consumptive dimensions of technology use, such as technological education for Repair, Reduce, Reuse and Remanufacture are marginalized or ignored. This is on one level counterintuitive, considering that many if not most technicians, technologists, and tradespeople are engaged in some form of these activities. This is not to suggest that these pedagogical activities should supplant the importance of new product design in the curriculum, but their absence in curricula signals that these are not important or valued technological activities.

These activities may be considered parochial since they have not yet been resignified as new, trendy, and worthwhile "high-tech" and "cutting-edge" skills. Product reuse and repair tend to carry a negative stigma in our materially rich culture. People who can afford to buy new products seldom think of repair and reuse as an option, after all, why repair something when you can buy a new one, often cheaper? The fact that many products are designed for quick obsolescence, with no replaceable parts and no system in place for their rehabilitation, is more of an indication that the manufacturer has externalized the costs in terms of disposal, pollution, and lost materials onto the public and the environment at large.

Despite this stereotype, the activities of remanufacture, reuse and repair are forms of product stewardship, keeping products out of landfills and incinerators prematurely and promoting eco-efficiency. They also provide important contexts and opportunities for students to reflect upon new design and the worthwhile task of reengineering existing products to make them more cost efficient, lighter, stronger, more durable, and more ecologically benign. The closing of the material cycle in product manufacture-use-reuse also reinforces the message that these activities make sense from an ethical and energetics-ecological perspective. Recycling and reusing materials save a considerable amount of energy and reduce the bioaccumulation of toxins which leach from landfills or drift out of incinerators. All of these activities are part of an important sustainable and expanding economic and social activity.

The fourth *product paradigm* factor is revealed when products are framed as only expanding human possibilities, never restricting them. In this perspective products only solve problems, they don't create them. The ubiquity of advertising supports our almost religious belief in technological-material progress, and suggests that there is a product to solve each of life's problems:

> By implication, material solutions can supplant social, psychological and spiritual ones, and the cumulative output of multinational corporations represent the pinnacle of all human achievement (Kanner & Gomes, 1995, p. 84).

The notion that human capabilities are *only* enhanced through technologies is one with deep historical roots. After all, we don't initially consider that the design and manufacture of a product will restrict the variety of choices available to users.

Borgmann's (1984) "device paradigm" also suggests that technology can form a constraining pattern (Higgs, 2003) to our lives. According to the device paradigm, the technological *device* serves to separate means from end, thereby producing a commodity for our convenient enjoyment while also simultaneously removing the machinery of its production into our conscious background. When we fail to reflect on the implications of this separation, or to even acknowledge it's reality, we further disengage ourselves from our bioregion, our community, and our lived history. The promise and the power of technological devices according to Borgmann emanate from their promise of liberation and enrichment. Technological devices *promise* to liberate us from drudgery. Our time thus freed is available for personal enrichment, but as Higgs (2003) points out, this time is often used for intensified work and more consumption. Reestablishing sustained "focal practices" into our lives is, according to Borgmann, integral to generating meaning and connection and a sense of sufficiency.

The fact that the span of our perceptions, feelings, and awareness can be both broadened and narrowed or restricted through the use of technology is not given adequate attention in the *product paradigm*. Ihde has pointed out that: "tools amplify certain aspects of normal embodied experience while simultaneously reducing others"(Ihde, 1985). The dominant legitimized discourses within technological education have essentially been situated in a mechanistic, modernist, and conservative worldview (Petrina, 2003;1998), and as such are complementary and congruent with the historically authoritative account of expansionistic neo-liberal economics. This worldview and the associated narrative of human beings as rightful dominators and plunderers of all living systems on a resource limitless planet, has been discredited as simplistic and dangerous.

Confronting "Crude" Products through Product Critique

Central to a reconceptualization of the *product paradigm* is the "interdiscipline" of technological criticism described by Petrina (1998) and "*critic competence*" (Layton, 1993). This form of critique confronts ecological, social, and ethical dimensions of technology as well as the precepts guiding design:

> The critic of technology asks fundamental questions about what a technology offers (perception and description), what it means with its embedded values (analysis and interpretation), and the technology's worth (judgment) (Petrina, 1998, p. 122).

It becomes increasingly indefensible for technological education to ignore fundamental ethical and moral issues and questions related to our perceived "right" to consume and pollute the planet in orders of magnitude greater than citizens of the developing world.

Engaging in product critique is a form of connoisseurship that helps young people appreciate the attributes of products that are durable, well designed, and ecologically responsible. It also helps them avoid the mediocre and/or irresponsible products of technology. Critique and connoisseurship enable young people to identify products that are not designed for long-term human and ecological health but which nevertheless meet *minimal* standards with respect to attractiveness, performance and longevity as "unintelligent and inelegant crude products" (McDonough et al., 2002, p. 37). Teachers have a responsibility to help young people characterize and identify for themselves the nature of the "crude products" that surround us and overflow from our shopping malls. Students thus empowered are less likely to accept or support substandard, short-term, environmentally destructive product culture. Until young people learn to understand crude product culture as being both inauthentic and contributors to the false consciousness of the *product paradigm*, their ability to re-create our built environment into a genuinely sustainable environment will be made that much more difficult. For example, transforming suburban sprawl into healthier, more diverse neighborhoods requires a fundamental reassessment of car culture and public transportation.

This paper has outlined the major problematic characteristics of the product paradigm. Educating teachers to critically assess and challenge the product paradigm is not straightforward or unproblematic. Confronting worldviews and value-systems that have uncritically incorporated and reproduced facets of the *product paradigm* make it all the more difficult to question its fundamental tenets. Gladwell (2000) suggested that ideas, products, messages, and behaviors spread just like viruses do, and eventually the aggregate effect of small changes trigger a system "tipping point," leading to large scale change in the system. Technological education is still some distance from a tipping point with respect to a transition to sustainable product perspectives and practices. Advancing a sustainability paradigm will require that teachers take a critical look at the implications of the *product paradigm*.

Transforming the troubling socio-technological trends described here into a sustainable and hopeful future will require a positive but pragmatic vision and a concerted effort by the technological education community. Knowing these realities without acting in some form of common purpose effectively amounts to civic and global irresponsibility. One of the most important transformations involves a re-thinking of the nature of the product form and its culture in the manner in which we teach technology in secondary schools. Mitcham's observation that: "technology, or the making and using of artifacts, is a largely unthinking activity" that "emerges from unattended to ideas and motives" to produce "unreflected-upon objects" (Mitcham, 1994, p. 1), is increasingly indefensible when modern production systems scour the globe for the lowest priced materials and labor and leave a wake after their presence. Although Leopold's axiom may seem like "common sense," we as creators of the technosphere need to stop our tinkering lest it lead to global biosphere collapse.

References

Anderson, D. (2004). From productivism to ecologism. *UNESCO-UNEVOC Bulletin*, *9*(3). UNEVOC International Centre for Technical and Vocational Education and Training. Retrieved January 2005, from http://www.unevoc.unesco.org

Borgmann, A. (1984). *Technology and the character of contemporary life.* Chicago: University of Chicago Press.

Buchanan, R. (2001). The problem of character in design education: Liberal arts and professional specialization. *International Journal of Technology and Design Education*, *11*(1), 13-26.

Canadian Broadcasting Corporation, Staff Writer (2005, January 5). Ford SUV televisions commercial aired on CBC National News. Toronto: Canada.

Conway, R. (2000). Ethical judgments in genetic engineering: The implications for technology education. *International Journal of Technology and Design Education*, *10*, 239-254.

Csikszentmihalyi, M. & Rochberg-Halton, E. (1995). *The meaning of things, domestic symbols and the self.* Cambridge: Cambridge University Press.

De Vries, M. (1997). Science, technology and society: A methodological perspective. *International Journal of Technology and Design Education*, *7*, 21-32.

Deffeyes, K. S. (2005). *Beyond oil*. New York: Hill & Wang.

Doucet, C. (2005, May 23). Cultural lag, a lethal drag. *Globe and Mail.* Retrieved May 24, 2005, from http://globeandmail.ca

Durning, A. T. & Ryan, J. C. (1997). *Stuff, the secret life of everday things.* Seattle: Northwest Environment Watch.
Flowers, J. (1998). Problem solving in technology education: A Taoist perspective. *Journal of Technology Education*, *10*(1), 20-26.
Furby, L. (1991). Understanding the psychology of possessions and ownership. *Journal of Social Behaviour and Personality*, *6*, 457-467.
Gardner, G., Assadourin, E., & Sarin, R. (2004). The state of consumption today. In L. Starke (Ed.), *State of the World 2004* (pp. 3-21). New York: W.W. Norton.
Gladwell, M. (2000). *The tipping point: How little things can make a big difference.* Boston: Little Brown & Company.
Guber, D. L. (2003). *The grassroots of a green revolution.* London: The MIT Press.
Hawken, P., Lovins, A. B., & Lovins, H. L. (1999). *Natural capitalism.* Boston: Little, Brown and Company.
Higgs, E. (2003). *Nature by design*. London: MIT Press.
Ihde, D. (1985). Technology and cultural variations. In C. Mitcham (Ed.), *Research in philosophy and technology, Volume 8* (pp. 17-33). Greenwich Connecticut : JAI Press.
Intergovernmental Panel on Climate Change (2001). *Climate change 2001: The scientific basis.* Cambridge: Cambridge University Press.
International Technology Education Association. (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.
Jones, A. (1997). An analysis of student existing technological capability: Developing an initial framework. *International Journal of Technology and Design Education*, *7*, 241–258.
Jones, A. (1997). Recent research in learning technological concepts and processes. *International Journal of Technology and Design Education*, *7*, 83-96.
Kanner, A. D. & Gomes, M. E. (1995). The all-consuming self. In T. Roszak, M. Gomes, & A. Kanner, (Eds.) *Ecopsychology, restoring the earth, healing the mind* (pp 77-91). San Francisco: Sierra Club.
Krippendorff, K. (1996). On the essential contexts of artifacts or on the proposition that 'design is making sense of things.' In V. Margolin & R. Buchanan (Eds), *The idea of design* (pp. 156-184). Cambridge: MIT Press.
Lankshear, C.; Gee, J. P.; & Hull, G. (1996). The new work order behind the language of the new capitalism. Boulder Colorado: Westview Press.
Layton, D. (1993). *Technology's challenge to science education.* Buckingham: Open University Press.
Leopold, A. (1993). *Round River*. New York: Oxford University Press, pp. 145-146.
McDonough, W. & Braungart, M. (2002). *Cradle to cradle*. New York: North Point Press.

McLaren, S. V. (1997). Value judgements: Evaluating design - A Scottish perspective on a global issue. *International Journal of Technology and Design Education*, *7*, 259–278.
McLaughlin, L. (2005, March 15). Hobbit houses. *Time Magazine Canadian Edition*. Retrieved March 30, 2005, from http://global.factiva.com
Mitcham, C. (1994). *Thinking through technology: The path between engineering and philosophy*. Chicago: University of Chicago Press.
Mitcham, C. (2001). Dasein versus design: The problematics of turning making into thinking. *International Journal of Technology and Design Education*, *11*(1), 27-36.
Monbiot, G. (2005, Tuesday February 15). Mocking our dreams: The reality of climate change is that the engines of progress have merely accelerated our rush to the brink. *The Guardian*. Retrieved February 15, 2005, from http://www.guardian.co.uk.
Norman, D. A. (2004). *Emotional design.* New York: Basic Books.
National Research Council. (1999). *Our common journey: A transition toward sustainability.* Washington, D.C: National Academy Press.
Paquet, L. B. (2003). *The urge to splurge.* Toronto: ECW Press.
Petrina, S. (1998). Multidisciplinary technology education. *International Journal of Technology and Design Education*, *8*, 103-138.
Petrina, S. (2000). The political ecology of design and technology education: An inquiry into methods. *International Journal of Technology and Design Education*, *10*, 207–237.
Petrina, S, & Dalley, S. (2003). The politics of curriculum reform in Canada: The case of technology education in British Columbia. *Canadian Journal of Science, Mathematics and Technology Education*, *3*(1), 117-144.
Petrina, S. (2003). Two cultures of technical courses and discourses: The case of computer aided design. *International Journal of Technology and Design Education*, *13*, 47–73.
Quart, A. (2004). *Branded: The buying and selling of teenagers*. New York: Basic Books.
Sachs, W. (2003). *Environment and human rights*. Wuppertal, Germany: Wuppertal Institute.
Sanders, L. (2005). No boom, but '06 will be better than a bust. *Advertising Age*, 76(50): 10.
Schor, J. (2004). *Born to buy*. New York: Scribner.
Schwartz, B. (2004). *The paradox of choice: Why more is less.* New York: Harper Collins.
Smil, V. (1997). Global population and the nitrogen cycle. *Scientific American*, *277*(1), 76-81.
Smith, T. M. (1998). *The myth of green marketing.* Toronto: University of Toronto Press.
Stein, S. J.; Docherty, M.; & Hannam, R. (2003). Making the processes of designing explicit within an information technology environment. *International Journal of Technology and Design Education*, *13*, 145–170.

World Resources Institute. (2005). *Millennium ecosystem assessment synthesis report.* Washington, DC.: Author.

The Use of Innovative Methods to Deliver Technology Education Laboratory Courses via Distance Learning: A Strategy to Increase Enrollment

Hassan Ndahi

Introduction

Distance learning is not a recent innovation in education; correspondence courses having been used for over 150 years, but new interactive technologies are providing new opportunities and strategies for teaching at a distance (Smaldino, 1996). Several studies have compared face-to-face classrooms to distance classrooms in order to evaluate differences in student performance and quality of instruction. A meta-analysis of these studies showed that distance learning students performed equally well and some distance courses outperformed their classroom counterparts (Bernard et al., 2004).

This result has been consistent over many studies across many disciplines; advances in communication technology and innovative methods of delivery of instruction at a distance have challenged the idea that laboratory courses can only be delivered in a face-to-face laboratory setting. In engineering for example, Virtual Laboratories have been used to teach thermodynamics, electronic circuits, and other experimental courses as well (Baher, 1999, Griffioen, Seales, & Lumpp, Jr., 1999). Programs in nursing, engineering, technology, and other sciences are beginning to use different technologies and innovative methods to deliver courses via distance learning methodology in order to reach students in different locations and boost enrollment. A survey of online distance learning programs revealed a large increase in student enrollment (Carlson, 2004; Gayle, Cook & Kwanghee, 2003; Laughlin, 1997). The availability of distance courses has made it possible for some people to attend college because courses are accessible within their locality or the time of course delivery is convenient to them. This opportunity for learning has not been without critiques of the quality of such instruction, and rightly so with any form of instructional delivery.

Quality issues are a major concern for those who intend to pursue degree programs via distance learning, especially with the proliferation of distance learning programs. Although it is difficult for academics to agree on specific standards that constitute quality in distance learning, nonetheless, attributes such

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as accreditation standards for programs, evaluating students' experiences, teacher-student interaction, student-to-student interaction, learning resources for the learner, learner assessment and performance, instructional resources for faculty, faculty training, and learner satisfaction are valid criteria (Dahl, 2003; McIsaac, & Craft, 2003; Mann, 1998). These and many other factors can determine the quality of delivery of instruction in both distance and face-to-face classrooms.

The Problem

Enrollments in technology education at the college level have been declining (Daugherty, 1998; Hill, 1999; Isbell & Lovedahl, 1989). The declining enrollment has resulted in a shortage of technology education teachers across the country. Several years ago the projection was that by the year 2005, 13,089 technology education teachers would be needed to match the increasing enrollment of students in our secondary schools and the shortfall caused by teacher retirements (Ndahi & Ritz, 2002; Weston, 1997). Technology teacher educators need to investigate ways to increase the enrollments in their programs, or the profession may fail to provide technology teachers in the future (Ritz, 1999). Exploring alternative methods of delivery to reach prospective students at their place of work or in their locality will further meet the objective of providing education to all of society.

Technology education programs with a history of hands-on learning at the undergraduate level have been slow to implement distance learning techniques and strategies (Flowers, 2003). This study examines ways in which laboratory courses are delivered through the use of distance learning technology and other innovative methods.

Research Objectives

The objectives of the study were to:

1. Determine the extent to which laboratory courses are delivered via distance learning in technology and engineering programs,
2. Determine the laboratory courses offered via distance learning in technology and engineering programs,
3. Determine the types of distance learning technologies and innovative ways used to deliver laboratory courses in technology and engineering programs, and
4. Determine the support services provided to students and faculty using the distance learning technology.

Research Design and Methodology

This study used descriptive research in order to gain information as to how laboratory courses are taught via distance learning in technology and engineering programs. Quantitative and qualitative data were collected to provide for a balanced assessment and interpretation of current and developing practices. Data gathering involved a one-time collection of specific information and a visit to one selected site for follow-up and data gathering through interviews and observation where necessary.

Population and Sample

The population for the study was drawn from universities in the United States and a university in the United Kingdom. A purposive sampling method was used to select these universities (Fraenkel & Wallen, 1993). The selected programs were delimited to mechanical engineering and industrial technology programs that offered distance learning courses, especially laboratory courses. The study sample comprised 75 department heads and program leaders from 64 selected universities in the United States that offer distance learning courses and have mechanical engineering and technology programs. One university in the United Kingdom was selected because it offered all its undergraduate engineering courses at a distance. The departments selected were the Environmental and Mechanical Engineering Department and the Department of Education and Language Studies: Center for Research in Teacher Education. The latter has a design and technology program similar to many technology education programs in the U.S.

Instrumentation and Data Collection

The survey instrument developed by the researcher to achieve the objectives of the study was modeled from the Ndahi & Ritz (2002) study that analyzed distance learning in industrial and technical teacher education programs. Both open and close-ended questions were asked. In order to determine its face and content validity, the instrument was reviewed by a panel of three professors for appropriate wording and clarity. The instrument was then administered to faculty engaged in distance learning from five institutions. As a result, one question on the survey was re-worded to elicit a more direct answer.

Heads of departments and program leaders from the selected universities were mailed a questionnaire with a self-addressed return envelope. A follow-up questionnaire was sent electronically to department chairs and program leaders who did not respond to the initial survey. The initial return was 49%, but after the follow-up questionnaire was sent, it rose to 58.6% (41 department chairs and program leaders).

Data Analysis

Descriptive statistics in the form of frequencies and percentages were used to analyze the quantitative data. The open-ended data were coded and organized based on questions on the survey (Stainback & Stainback, 1988). A narrative summary of the responses explained the data. Information not relevant to the study was deleted.

Extent of Laboratory Courses Taught Via Distance Learning

To determine the extent to which laboratory courses were taught via distance learning, the researcher looked at the number of departments of engineering that offer courses via distance learning. Although all the universities selected for the study offered distance learning courses in other programs, not all offered distance learning courses in their mechanical engineering and technology programs, especially laboratory courses.

Based on the responses, the data indicated that 20 departments of engineering and technology, representing 48.8%, offered distance learning courses. Further analysis of the data revealed that 15 departments (36.6%) offered non-laboratory courses, and only 5 departments (12.2%) offered laboratory courses (see Table 1).

Table 1
Extent to Which Laboratory Courses Are Taught Via Distance Learning (n=40)

Item	n	%
Technology and Engineering Departments offering distance learning courses	20	48.8
Non-laboratory courses	15	36.6
Laboratory courses	5	12.2

Laboratory Courses Offered Via Distance Learning in Technology and Engineering Programs

Of the five programs that offered laboratory courses via distance learning, four departments offered such instruction at the graduate level. Course titles included network management, information technology, and digital communication. Only one department offered courses at both graduate and undergraduate levels.

At the UK-selected university, the following courses were offered in the departments of Mechanical Engineering and Materials Engineering:

> Engineering Mechanics - Solids; Introduction to Thermofluid Mechanics; Environmental Monitoring; Modeling and Control; Engineering Mechanics - Solids and Fluids; Heat Transfer - Principles and Applications; Manufacturing Technology; Failure of Stress Materials; Inside Electronic Devices; and Engineering in Action.

Most of these courses have extensive laboratory hands-on activities.

Distance Learning Technologies and Innovation in Laboratory Course Delivery

The five departments that offered laboratory courses via distance education used combinations of a variety of instructional technologies. The technologies most used were Interactive Microwave TV, (two-way audio and video), compressed video, Internet, CD's, computer software (virtual software), and video tapes.

At the selected University in the UK, interviews were conducted on site with faculty and staff. Teaching materials, student portfolios, and a secured Web site were observed. In addition to the Internet, CD's, and video, the university used the following innovative ways to deliver laboratory courses:

Residential and Summer Schools. Residential and summer schools serve a similar purpose; the difference is the duration. The summer school is one week long and combines labs, lectures, and problem sessions. In general, these schools provide four key features, providing the opportunity for students to:

1. undertake experimental work considered too hazardous for a student working at home.
2. undertake lab work using more sophisticated equipment, or equipment too expensive to provide at home.
3. undertake assessed lab-work.
4. work together.

Some courses even arranged to take students on a study trip, perhaps to a company with special processes, or to a geographic site of interest.

The Learning Kit. A specialized Learning Kit enables students to learn the basic techniques and terminology of the subject being taught. The activities introduced in the Learning Kits are designed to be undertaken in the "average family kitchen." Students are advised about any equipment they need to purchase for themselves (the University has rules specifying the upper limit of expenditures). Other equipment such as a soldering iron, a volt meter, pliers, etc. is provided to students. Carefully prepared notes or instructions guide students through measurement and construction activities such as how to create an electronic circuit. The notes specify things that might go wrong and how to correct them. Computer software may also be used to perform some lab activities by means of simulation in a virtual environment.

Demonstration Laboratory. The demonstration laboratory introduces students to the work they are going to undertake, illustrating how to proceed, how to make particular types of measurements, etc. It also covers topics considered too dangerous for students or situations in which the equipment is not available at the residential school. Many of these demonstrations are recorded on video to control both the process taught and the quality of the teaching across numerous groups of students at different centers.

Support Services Provided to Faculty and Students Engaged in Distance Learning

All the departments that offer distance learning courses offer support services to students and faculty. The support services include e-mail systems, graduate assistants, course Websites, proctors, telephone conferencing, electronic library materials, and instructional designers to work with faculty to design and develop courses. At the selected university in the UK, however, interviews with instructional designers and faculty revealed the significant role played by instructional designers. Although they are not the content experts, they advise faculty, for example, on how information is presented on a Website or the format in which the information is presented. The purpose is to maintain a standard format and quality in print materials, including electronic resources.

The selected university in the U.K also provides a support service to faculty that is unique from other institutions in this study: *Staff tutors* who are regionally based to provide the link between the university faculty and students within the regions. The staff tutors have a key role in quality assurance, especially in facilitating effective teaching of the university faculty's courses, and are responsible for the selection, monitoring, and staff development of part-time Associate Lecturers. They contribute to faculty research and the development and presentation of courses. The staff tutors are highly qualified in their fields, and as such, bridge the distance gap between the university faculty and students at different locations.

Results

This study sought to identify courses that have hands-on lab activities and are delivered via distance learning in technology and engineering programs. Data were collected and analyzed from degree programs (BS, MS, and PhD) in engineering and technology. While the survey return of 58.6% is acceptable for reporting, the results cannot be generalized to technology and mechanical engineering departments beyond those sampled in this study. However, the results can serve as a basis for further investigation with a more comprehensive sample.

Laboratory Courses Offered Via Distance Learning

It is important to determine the nature of the laboratory courses and the extent to which they are delivered via distance learning in technology and engineering programs in order to learn from the experiences of institutions and programs. Although the results show that 15 departments of technology and engineering programs (48.78% of respondents) are offering distance learning in non-laboratory courses, only 5 departments (12.19%) are offering laboratory courses. Most of the non-laboratory courses are being offered at the graduate level.

At the selected university in the U.K, all courses in the departments of Mechanical Engineering and Engineering Materials are being offered via distance learning. Some of the courses require intensive, hands-on laboratory activities while some do not. When laboratory activities are part of the course requirements, the faculty decides whether to use a learning kit or demonstration lab or to invite students to the residential or summer school. This decision is made during the planning and development of the course. To maintain quality standards for all courses, faculty must have an intended course peer-reviewed by faculty from institutions teaching similar courses in a non-distance setting. Generally, when courses do not receive a favorable review they are not taught. It takes between two and three years for faculty to get a course accepted for distance delivery by the university.

Technology and Innovative Ways Used to Deliver Laboratory Courses

The investigation did not uncover new technology to deliver laboratory courses. Instead, these courses were delivered using the same methodology for distance learning courses in general. This included mainly television, the Internet, printed materials, video tapes, and compressed video. What departments are doing differently is combining various technologies and using other innovative ways to deliver courses. The university in the UK used most of the instructional technology mentioned, but also employed other innovative methods such as the Residential and Summer Schools, Learning Kits, Field Trips, and the Demonstration Laboratory. The combination of these innovative methods with the numerous technologies available enabled the university to deliver all its laboratory courses in engineering at a distance.

Support Services Provided to Faculty and Students

Support services to faculty and students can make a difference in the effectiveness of both the teaching and learning process of distance education. The support services included the availability of electronic communication systems, telephone conferencing, proctors, graduate assistants, and instructional designers. Most of the departments that responded to the survey provided similar support services. The UK university has one unique support service which was the use of tutors to facilitate teaching and learning for the students and to serve as a link between the university and the students. The tutors are also responsible for selecting, monitoring, and developing the skills and knowledge of part-time lecturers and they contribute to the research, development, and the delivery of courses.

Discussion

If technology education programs are confronting dwindling enrollment and a shortage of teachers, it is fair to say that the profession or departments preparing technology education teachers should consider options that have boosted enrollment in other fields. Certainly, we can close the teacher shortage gap in the future if student enrollment in our programs increases. Increasing enrollment, though, is not easy considering the difficulty of attending college for some adults because of geographic location, work schedules, and personal responsibilities (Newman, 1997). It is imperative that administrators and instructors in our programs consider alternative methods of delivery of instruction, using alternatives to the traditional, face-to-face classroom approach.

Among the many strategies that can help increase student enrollment in technology education is to take the program to the prospective students instead of the students going to the program. It is true that a big obstacle to delivering technology education laboratory courses is teaching the hands-on activities. Programs in science and engineering are facing the same problem: it is difficult to conduct experimental work because the scope of many experiments is limited by issues of safety for students and the cost and complexity of instruments and devices required for laboratory activities (Dunne, Farrel, McDonald, & O'Dowd 1999; Gustafsson, 2002). This study clearly indicated the limited extent to which technology and engineering programs are delivering laboratory courses via distance learning. Nonetheless, the efforts made in delivering non-laboratory courses are encouraging.

Advances in communication technology have made it possible to deliver laboratory courses in technology and engineering (Liou, Soelaeman, & Leung, 1999; Hodge, Hinton & Lightner, 2001; Alessandro, Milano, & Vincenzo, 1999). Although, some of the technologies are very effective in delivering some courses, others are not (Joler & Christodoulou, 2001). Combining different technologies with other innovative ways has worked well for some institutions. The UK university, by using innovative strategies such as the Residential and Summer Schools, Field Trips, Learning Kits, and Demonstration Laboratories in combination with other technologies, is able to teach all its laboratory courses via distance learning to its nearly 200,000 students within and outside the UK. Distance learning is not meant to replace a face-to-face classroom, but it is one major way to make education more accessible to society. As advances in communication and digital technology continue, residential or demonstration labs may someday be replaced with comparable experiences provided through distance education.

Concerns raised by academics and the general public about distance education continue to surface, often relating to the quality of the courses. Institutions engaged in distance learning have methods for evaluating the quality of their instruction. There are no universal standards to measure the quality of distance education delivery; institutions generally set their own criteria (Dahl, 2003; McIsaac, & Craft, 2003; Mann, 1998). At the selected university in the UK, between two and three years are spent in preparation, evaluation, and testing of a course before it is finally delivered to students. Ironically, perhaps, most face-to-face courses do not undergo such rigor, even though both delivery methods might use the same instructional technology.

Support services are an integral and essential component in distance teaching. The fact that students are at a distant location means they will require services that will bridge the gap between them and their instructor. These services could include any medium of communication or human assistance that is accessible to students. For example, one concern with laboratory courses is safety. In a face-to-face class, the instructor may observe practices that can cause injury to students and take corrective action before any harm is done. To circumvent this issue, some distance classes are using computer simulations and virtual laboratories, while in others computers are being used to control or manipulate the required equipment at a distance.

Support services such as telephone conferencing, e-mail, proctors, graduate assistants, and digital libraries are other ways to link students with the faculty. This connection is critical to students in any form of distance learning situation, regardless of the technology used. The staff tutor used in the UK and mentioned earlier seems to be a unique and effective way to link the students and faculty. The person serving in this manner is highly qualified in content of the course and is therefore able to provide informed assistance at any time to a student.

As the advances in communication technologies and instruction continue, more and more laboratory courses will be delivered via distance learning.

Although great strides have not been made in teaching laboratory courses, it is encouraging to note that nearly half of the responding departments of technology and engineering are engaging in distance delivery of their courses. More importantly, some of these departments are combining different technologies and other innovative methods to deliver hands-on laboratory courses. To reiterate, distance learning is not meant to replace face-to-face classroom instruction, as many skeptics have assumed, but to provide an alternative means of learning for the large population of non-traditional students. This reform in education deserves the attention of teacher educators in general as well as those involved in technology education.

References

Alessandro, F. Milano, P. & Vincenzo, P. (1999). Simulation tool for virtual laboratory experiments in a WWW environment. *Transactions on Instrumentation and Measurements, 48*(3), 741-746.

Baher, J. (1999). Articulate virtual labs in thermodynamics education: A multiple case study. *Journal of Engineering Education, 88*(4), 429-431.

Bernard, R.M., Abrami, P.C., Lou, Y., Borokhovski, E., Wade, A. Wozney, L. et al. (2004). How does distance education compare with classroom instruction? A meta-analysis of the empirical literature. *Review of Educational Research 74*(3), 379-439.

Carlson, S. (2004 November, 26). Online education survey finds unexpectedly high enrollment growth. *The Chronicle of Higher Education, 51*(14), p. A30.

Dahl, J. (2003). Evaluating distance education in the 21st century. *Distance Education Repor*t, *7*(8), 4-5.

Daugherty, M.K.(1998). A recruitment crisis: Strategies for affecting change. *The Technology teacher, 5*7(7), 21-26.

Dunne, J., Farrel, T. McDonald, D. & O'Dowd, R. (1999). Introducing optoelectronics through automated characterization of devices and virtual measurement software. *Transactions on Education, 42*(4), 367 –371.

Flowers, J. (2003). Under Review: Handbook on distance education. *Journal of Industrial Teacher Education, 40*(4), 64-72.

Fraenkle, J.R. and Wallen, N.E. (1993). *How to design and evaluate research in education* (Revised). New York: McGraw-Hill.

Gayle, W.B., Cook, P. & Kwanghee, D. (2003). RN to BSN program from traditional to online delivery. *Nurse Educator, 28* (3),121-126.

Griffioen, J., Seales, W.B. & Lumpp, Jr. J. E (1999). Teaching in real-time wireless classrooms. *Journal of Engineering Education*, *88*(4), 397-400.

Gustafsson, P. (2002). Physics teaching at a distance. *European Journal of Physics, 23(5)*, 469-474.

Hill, C.E. (1999). Signs of distress in technology education programs. *The Technology Teacher, 58* (7), 21-25.

Hodge, H. Hinton, H.S. & Lightner, M. (2001). Virtual circuit laboratory. *Journal of Engineering Education*. *90*(4), 507-509.

Isbell, C.H. & Lovedahl, G.G. (1989). A survey of recruitment techniques used in industrial arts/technology education programs. *The Journal of Epsilon Pi Tau,* *15* (1), 37-41.

Joler, M. & Christodoulou, C.G. (2001). Laboratories accessible through the internet. *Microwave Magazine, 2*(4), 99-103.

Laughlin, J. (1997). Serving new audiences with a master of science degree through distance education, *Journal of Family and Consumer Sciences, 98,* 11-15.

Liou, S. P., Soelaeman, H., & Leung, P. (1999). Distance learning engineering laboratory. *Computer Applications in Power, 12*(1), 6-12.

Mann, C.C. (1998). Quality assurance in distance education: the survey MA (TESOL) experience. *Distance Education, 19*(1), 7-22.

McIsaac, M.S. & Craft, E.H. (2003). Faculty development: Using distance education effectively in the classroom. *Computers in the Schools, 20*(3), 41-49.

Ndahi, H. B. & Ritz, J.M. (2002). Distance learning in industrial teacher education programs. *The Journal of Technology Studies, 18*(1), 64-69.

Newman, S. D. (1997). Applying total quality management to interactive distance learning. *Education at a Distance, 11*(2)*,* 17-20.

Ritz, J.M. (1999). Addressing the shortage of technology education teaching professionals: Everyone's business. *The Technology Teacher, 59*(1), 8-12.

Smaldino, S. (1996). Effective techniques for distance education instruction. Proceedings of Annual Conference on Frontiers in Education. Salt Lake City

Stainback, S & Stainback, W. (1988). Understanding and conducting qualitative research. Reston, VA: The Council for Exceptional Children

Weston, S. (1997). Teacher shortage-supply and demand. *The Technology Teacher, 57*(1), 6-9.

A Delphi Study to Identify Recommended Biotechnology Competencies for First-Year/Initially Certified Technology Education Teachers

Donald G. Scott, Barton A. Washer, and Michael D. Wright

Background

The world is a dynamic environment driven by technology that challenges each individual in a unique way. No longer is the ability to read and write sufficient because technological change affects nearly every aspect of one's life from "enabling citizens to perform routine tasks to requiring that they are able to make responsible, informed decisions that affect individuals, our society, and the environment" (International Technology Education Association [ITEA], 2003, p. 1). To "combat uncertainties about biotechnology and technology transfer firsthand knowledge of these technologies must become part of the education of each child" (De Miranda, 2004, p. 78). As a result of these technological developments, a challenge to all classroom teachers is to meet the needs of a diverse K-12 learning population. Technology education (TE) teachers in particular have been challenged to prepare students for life in a society dominated and driven by technology. To strengthen and ensure the future vitality of the United States' human resources and biotechnological enterprises, educators and professionals in the field of biotechnology must work together to develop competencies that meet students' needs (California State University Program for Education and Research in Biotechnology, 2001). To meet these challenges, technology stakeholders have collaborated to develop a variety of technology literacy standards and teaching methods. In particular, the ITEA published *Standards for Technological Literacy: Content for the Study of Technology* (*STL*) (ITEA, 2000). This document established a definition of technology, technological literacy, and the content standards needed for K-12 classrooms.

The *STL* (ITEA, 2000) presented a "vision of what students should know and be able to do in order to be technologically literate" (p. vii) through 20 content standards for grades K-12. The ITEA publication also established content benchmarks for the core areas of technology. One of the core

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technology content areas addressed by the *STL* is biotechnology. The *STL* Standard 15 states that "students will develop an understanding of and be able to select and use agricultural and related biotechnologies" (ITEA, 2000, p. 149). This standard proposed that secondary (grades 9-12) students should be able to study the effects of waste and pollutants, discuss the need for government regulations, and conduct research and present their findings on the positive and negative effects of a process, product, or system in the field of biotechnology.

The *STL* Standard 15 (ITEA, 2000) also established benchmarks (written statements that describe the specific developmental components by various grade levels that students should know or be able to do in order to achieve a standard) for biotechnology. The benchmarks progressively build on one another throughout the elementary, middle, and high school levels. The four benchmarks addressed by this research state in order to select, use, and understand agricultural and related biotechnologies; students in grades 9-12 should learn that:

K. Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products.
L. Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering.
M. Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.
N. The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna (p. 155-156).

Dunham, Wells, and White (2002) asserted that "Few fields in the modern world have advances as rapid as those that have taken place in biotechnology" (p. 65). Yet, the *STL* (2000) did not identify an organized and validated list of biotechnology competencies for teacher education programs (nor was it intended to do so). Russell (2003) believed that few TE teachers have been instructed in biotechnology, and instructional strategies being used to teach biotechnology may be inadequate. Rogers (1996) also reported that only 3.5% of the institutions surveyed included biotechnology in their industrial/technology teacher education programs. Russell (2003) further stated "if current students were tested on all of the ITEA standards; it is likely that biotechnology scores would be lower than in some more traditional areas within technology education" (p. 30).

The Council on Technology Teacher Education (CTTE) Undergraduate Studies Committee also recognized there was a need to identify and establish technical competencies for technology teacher education programs. At the 2003 ITEA conference, the CTTE identified their goals for 2003-2004. One goal was to develop teacher education competencies for all core technology content areas. Recognizing the magnitude of this task, the Undergraduate Studies Committee agreed to begin with only one content area: biotechnology (grades 9-12) (C. P. Merrill, personal communication, March, 13, 2003). As a result, this research was conducted as a CTTE charge to identify, develop, and validate a list of critical biotechnology competencies. However, this study did not attempt to address how technology teacher education programs determine curriculum content or where biotechnology would fit into teacher education curricula. Rather, the findings of this research were to act as an initial starting point for the development and validation of biotechnology competencies.

Purpose of the Study

The problem driving this study was the lack of recognized and validated biotechnology competencies to be included in technology teacher education programs. Therefore, the purpose of this study was to identify, develop, and validate the critical biotechnology competencies that should be acquired by first-year/initially certified secondary TE teachers to enable them to include selected biotechnology content in their classrooms (grades 9-12) in alignment with ITEA Standard 15 (ITEA, 2000).

Research Methods

Research Design

This research incorporated a Web-based modified Delphi technique based on an initial competency list created from existing literature. The Delphi was used to consult a body of experts, gather information, and formulate a group consensus while limiting the complications and disadvantages of a face-to-face group interaction (Isaac & Michael, 1981). In addition, the electronic Delphi was used to reduce the potential for dominance by a panel member or distortions (i.e., “group-think”) arising from decisions based on panel member feedback (Clayton, 1997).

The primary purpose of choosing the Delphi technique was to obtain a consensus of opinion from experts knowledgeable in biotechnology. The Delphi exhibited three distinct characteristics useful for this study: anonymity, interaction with controlled feedback, and statistical group response. Through the Delphi, participant anonymity was secured allowing individuals to change their opinion on the subject matter while preventing them from being persuaded or inhibited (Clayton, 1997). Consistent with Wells (1994), an abstract explaining the context of the study was used as an informative measure. Using an abstract is an adaptation of the traditional Delphi technique; however, the characteristics (e.g., anonymity, controlled feedback, and statistical group response) consistent with committee problem-solving activities were maintained.

Achieving group consensus through the Delphi process is a function of the validity and quality of the initial competency selection process through the literature review (Custer, Scarcella, & Stewart, 1999). The literature review revealed extensive similarities in the core content organizers for biotechnology. Therefore, the advisory committee determined two rounds of feedback were sufficient for this study. Round One allowed the panel to recommend changes, suggest deletions, and/or make additions to a researcher-developed list of biotechnology competencies based on the literature review. Round Two sought panel member consensus on the biotechnology competencies proposed, revised, and deleted by Round One. To maintain bias control, the Web-based instrument and resulting data were maintained by an independent researcher who had no direct affiliation with the study. Upon completion of each round, the researcher disseminated only aggregate data for evaluation by the advisory committee.

Delphi Panel Selection

The selected Delphi participants who served on the panel represented a nationwide selection of "cross-disciplined" biotechnology stakeholders (biotechnology industry, organizations, and government personnel, technology teacher education faculty, secondary education technology teachers, and a graduate student). Potential panel members were identified from recommendations by biotechnology professionals and educators, input from the ITEA/CTTE Undergraduate Studies Committee, a call for participation and recommendations from ITEA's online list-serve (Idea Garden), and recommendations by the research advisory committee. Initial consideration for those nominated as a Delphi panel member was based on their knowledge of biotechnology content, ability to represent feasible yet diverse viewpoints, ability to communicate feedback to the research panel, and/or a demonstration of expertise in biotechnology that established each participant as knowledgeable (Finch & Crunkilton, 1999; Walker & Echternacht, 1992).

The selection process also focused on individuals actively engaged in the field of biotechnology. Consistent with (Sharp et al., 2003), the Delphi panel members were also considered based on the following criteria: (1) a demonstrated particular interest in the field of biotechnology by either service or research; (2) possessing previous experience in biotechnology in general practice; and/or (3) being recognized as biotechnology experts by their colleagues. Individuals who did not meet these criteria were excluded from participation.

Potential panel members were contacted via e-mail requesting voluntary participation in the study. The respondents who replied positively received a second e-mail that presented a detailed study overview, a letter of informed consent for their participation, and their Federal human subjects' rights as panel members. Consistent with Clayton's (1997) recommended Delphi panel size, 16 members (11 men and 5 women) were selected to participate in Round One of the study. The panel included two government employees associated with the field of biotechnology, two biotechnology organization/industry professionals, two medical professionals, four secondary TE teachers who actively included biotechnology content in their classrooms, four technology teacher education faculty, one graduate student whose program of study emphasized biotechnology content, and one consultant specializing in biotechnology and genomics.

Instrumentation

To maintain anonymity, panel members were provided a unique identification number and link to the instrument. Panel members were also provided a cover letter that included a Delphi introduction outlining the features of the instrument, an operational definition of biotechnology, a link to ITEA Standard 15 (ITEA, 2000), and a description of the scope of the research. For the purpose of this study, biotechnology was operationally defined as any technique that uses living organisms, or pairs of organisms, to make or modify products (e.g., genetic engineering, tissue culturing), improve plants or animals (e.g., transgenics, therapeutic human cloning, genetically modified foods, etc.), or to develop microorganisms for specific uses (e.g., genetic therapeutics, microbial structures and applications, agrichemicals) (ITEA, 2000).

The Delphi for Round One feedback was sought on a list of 31 literature-based biotechnology competencies and seven content organizers. Consistent with Custer, Scarcella, and Stewart (1999), the researcher-developed competency list was used to provoke discussion and serve as an initial starting point for the panel. The content organizers included Biotechnology Fundamentals, Bioethics, Environment, Genetic Engineering, Agriculture, Medicine, and Skills. The Delphi instrument provided panel members with three feedback options (*accept as is; delete, not needed; and change to*) for each item (see Figure 1).

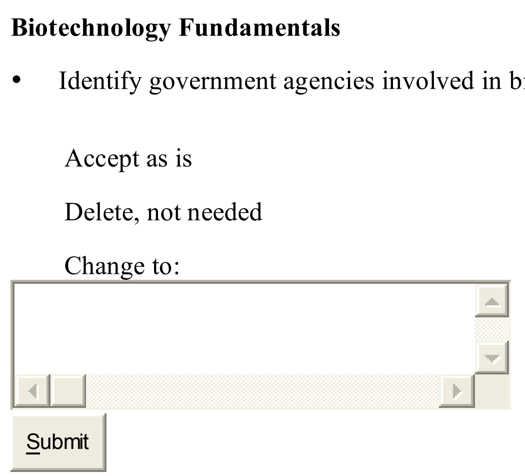

Figure 1. Competency feedback page.

To enter feedback, the panel members selected the option that best represented their recommendations. Once an option was selected and/or text added, the submit button was used to send the information to the database. When the “change to” option was selected, a text box (unlimited characters) was provided for the panel members’ feedback. The Delphi instrument allowed panel members to stop and restart as needed. If a panel member wanted to add a competency or content organizer, it could be entered into a designated text box. Panel members indicated completion by selecting the appropriate box which sent their final information to the database.

Round One of the Delphi instrument was accessible to panel members for a period of two weeks (October 20, 2003, through November 3, 2003). Following Round One, the Delphi Round Two consensus recommendations were posted online for ten days (November 14, 2003, through November 24, 2003) for panel member feedback. As stated in the letter of agreement to participate, panel members were not required to respond to competencies in areas in which they were not knowledgeable or comfortable. Those indicating completion without reviewing all 38 line items were not required to provide any justification or rationale for doing so, or provide feedback for Round Two.

During Round One, consensus was achieved all 38 line items with an overall acceptance rate of 80.4%, ranging from 68.8% to 93.8%. However, panel member feedback identified 46 recommended changes and/or additions to the Delphi competency list. Fifty-six percent (9 of 16) of the panel members responded to all 38 line items presented for Round One (see Table 1).

Table 1. *Round One panel member participation rates.*

Panel Member No.	No. of Items Completed	Percent	Bar Graph
1	38	100.0	
3	38	100.0	
4	38	100.0	
5	38	100.0	
6:	38	100.0	
11	38	100.0	
13	38	100.0	
15	38	100.0	
16	38	100.0	
10	36	94.7	
2	34	89.5	
7	29	76.3	
14	26	68.4	
9	25	65.8	
8	21	55.3	
12	13	34.2	

Based on the Delphi panel feedback, an amended list of eight content organizers and 44 competencies was posted online as the Delphi Round Two. The amended list included the following revisions from Round One: five changes and two additions were made to the Biotechnology Fundamentals content area; four changes and two additions were made to the Bioethics content area; two changes and one addition were made to the Environment content area; two changes and one addition were made to the Genetic Engineering content area; two changes and two additions were made to the Agriculture content area; four changes were made to the Medicine content area; one content area (Industry) and three new competencies were added, and the Skills content area was changed to Bioinformatics with three additional competencies added.

Twelve panel members provided feedback for the Delphi during Round Two, which concluded with all 52 line items achieving consensus with an overall group acceptance rate of 89.3%. This group acceptance rate constituted an increase of 8.9% above that posted for Round One. During the feedback period, 11 of the 12 panel members who participated indicated they had completed Round One. One of the 12 panel members reviewed only 22 of the possible 52 line items (42.3%) and did not indicate completion. The 11 panel member response rates for those who indicated completion during Round Two averaged 94.75%. Two of the panel members who did indicate completion also chose to exercise their option to not respond to all 52 line items. The response rates for these two panel members were 86.5% and 55.8% (see Table 2).

Table 2. *Round Two panel member participation rates.*

Panel Member No.	No. of items completed	Percent	Bar Graph
1	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
2	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
3	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
4	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
5	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
7	38	100.0	||||||||||||||||||||||||||||||||||||||||||||||||||||||
8	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
10	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
11	38	100.0	|||||||||||||||||||||||||||||||||||||||||||||||||||||||
6	45	86.5	|||||||||||||||||||||||||||||||||||||||||||||||
9	29	55.8	||||||||||||||||||||||||||||||

Seven changes (1.1%), no deletions, and six potential additions were recommended by the panel during Round Two. Six of the recommended changes were editorial and grammatical changes, which were accepted for clarification purposes. Five recommended additions were determined to exceed the scope of this study, were deemed to be instructional strategies rather than program competencies, or were already represented within the content organizers and/or existing competencies. The one competency added to the final list was in the Bioinformatics content area. A recommendation to drop the definition of Bioinformatics and change it into a competency was accepted and included on the final list..

Results

This study produced the following final list of eight biotechnology content organizers and 45 biotechnology competencies.

Biotechnology Fundamentals

1. Describe biotechnology and its global impact on society, culture, and the environment.
2. Identify and discuss international organizations and government agencies involved in biotechnology.
3. Compare and contrast the limitations and advantages of biotechnology.
4. Discuss biotechnology research, companies, careers, and career preparation.
5. Recognize and practice biotechnological safety procedures.
6. Identify and demonstrate biotechnology tools and equipment.
7. Define biotechnology and discuss its applications and its relationship with other technologies (i.e., medical, agricultural, and environmental).
8. Discuss the history of biotechnology and its impact on the future.

Bioethics

1. Identify the principles of ethics.
2. Discuss the bioethical issues arising from medical developments and processes (i.e., gene therapy and the patenting of life).
3. Discuss the bioethical issues arising from environmental developments and processes (i.e., inadvertent cross polination and bioremediation).
4. Discuss the bioethical issues arising from agricultural developments and processes (i.e., trangenics and genetically modified foods).
5. Describe ethical methods of addressing biotechnology issues.
6. Compare and contrast bioethics perceptions in the United States with perceptions in other countries.

Environment

1. Summarize how biotechnology impacts the environment.
2. Compare and contrast bioremediation methods with traditional remediation methods.
3. Discuss the environmental impact of biorestoration techniques.
4. Identify the biotechnologies suitable for waste disposal and treatment.

5. Compare and contrast physical and biological containment systems and how each protects the environment.

Genetic Engineering

1. Identify basic cell structures and research techniques.
2. Describe the process of genetic modification.
3. Illustrate a model of the genetic code.
4. Explain genetically modified foods, animals, and therapeutic human cloning.
5. Identify applications of genetic engineering, new and emerging, in the fields of agriculture and medicine.
6. Summarize the global impact of genome projects on civilization.

Agriculture

1. Appreciate the biosafety aspects of food and agricultural biotechnology.
2. Compare and contrast the potential benefits and risks of genetically modified foods versus traditional food production methods.
3. Identify emerging applications of biotechnology in plants and animals.
4. Identify how agricultural biotechnology reduces dependence on insecticides and reduces environmental and human exposures.
5. Summarize the impact biotechnology has upon agriculture.
6. Describe current social and political issues arising from bio-agriculture products and their effect upon international trade (e.g., genetically modified foods in Europe).

Medicine

1. Discuss the social, cultural, and political implications biotechnology has on medicine.
2. Identify genetic therapeutics and discuss how they have impacted health care.
3. Explain how immunology has impacted disease prevention.
4. Summarize how molecular medicine and health care technologies have impacted humankind.

Industry

1. Identify the emerging applications of biotechnology in industrial environments (i.e., new plastics and enzymes).
2. Compare and contrast the advantages and disadvantages of industrial biotechnology applications have upon humankind and environmental safety.
3. Describe the new industrial markets and business opportunities created through biotechnological products and processes.

Bioinformatics

1. Present an overview of bioinformatics (informational technology as applied to the life sciences, especially the technology used for the collection, storage, and retrieval of genomic and proteomic data).
2. Present related fields to bioinformatics (i.e., computational biology, cheminformatics, and medical informatics, etc.).
3. Identify the major tools and discuss the challenges facing bioinformaticians today.
4. Demonstrate exercises in developing and transferring data.
5. Facilitate open-ended design based problem solving in biotechnology.
6. Integrate the usage of computerized materials and the reading and understanding of technical materials.
7. Design basic laboratory exercises to demonstrate biotechnology (e.g., use of genetic markers and herbicide tolerances).

Discussion

The ITEA recognized the importance of including biotechnology content in secondary education classrooms by developing Standard 15 (ITEA, 2000) that established specific benchmarks for elementary, middle, and high school students. The CTTE Undergraduate Studies Committee also recognized the importance of including biotechnology with its 2003-2004 charge to identify, develop, and validate the critical biotechnology competencies that future secondary technology education teachers should possess to facilitate student learning under the ITEA *STL* benchmarks. However, standalone competencies do not establish how much biotechnology content is appropriate for student instruction, how biotechnology should be included in secondary education classrooms, or who teaches biotechnology content to students. Through the execution of this study, the identification, development, and validation of an initial set of critical biotechnology competencies for technology teacher education programs was accomplished. Yet, the steps needed to obtain further feedback and acceptance by those with a vested interest in the future of biotechnology education is unknown.

While ITEA Standard 15 and the charge by the CTTE Undergraduate Studies Committee served as the catalysts for developing the biotechnology competencies that were the focus of this research, the competencies identified may exceed the breadth and depth of the Standard. Specifically, the content organizers Industry and Bioinformatics, with their related competencies, may not be included in the *STL.* Therefore, there is a need for continued study and debate by all biotechnology education stakeholders.

Biotechnology Content and Teacher Education Programs

Technology teacher education programs are structured by a core of required and elective courses based on a total number of cumulative hours required for a bachelor’s degree. Currently, most technology teacher education degree programs being offered do not include biotechnology content (Rogers, 1996; Russell, 2003). Adding additional hours to existing programs will require content to be either eliminated, or hours to be added to programs of study.

Determining how to integrate biotechnology into existing teacher education programs will become more prominent in the future (Dunham, Wells, & White, 2002). However, including biotechnology content within the structure of current technology teacher education programs, compounded by the procedures required to change program content or add additional hours to degree requirements, may be difficult to accomplish. The appropriateness and feasibility of including biotechnology content in technology teacher education programs, either as standalone TE courses or through creating partnerships with biology or traditional science programs, should be explored.

Biotechnology stakeholders may also argue that teaching biotechnology content in secondary classrooms should remain in traditional science and biology programs rather than TE classrooms. In contrast to this opinion, the development of ITEA's Standard 15 (ITEA, 2000) supports the position that technological literacy includes biotechnology content (or any other core area) that should be included in secondary education regardless of who delivers it. Including biotechnology content requires competent and literate teachers who possess the critical biotechnology competencies needed to facilitate student learning. As a result, the future of biotechnology in the secondary educational system is contingent upon the preparedness of *all* teachers who are charged to deliver biotechnology content in their classrooms. This may create problems for technology teachers who are currently being ill-prepared by many technology teacher education programs (Russell, 2003). To facilitate teaching biotechnology in secondary education, TE teachers need to be adequately prepared to deliver selected biotechnology content.

Rogers (1996) and Russell (2003) also report that many institutions offering TE teacher education programs have chosen to completely ignore biotechnology content. It may be unlikely that those ignoring biotechnology will accept or recognize the competencies identified and validated by this study as the definitive set. Furthermore, it may also be unlikely those TE teacher education programs will move towards including biotechnology based on this study's results. Regardless of whom the task of including biotechnology in secondary education classrooms falls upon, the critical biotechnology competencies identified and validated by this research may become instrumental in teacher education programs that prepare future secondary educators including, traditional science teachers, TE teachers, or others.

The opinion that biotechnology content should be taught across multiple disciplines, which includes TE, supports ITEA Standard 15 and this study's purpose to identify, develop, and arrive at a consensus on the critical biotechnology competencies needed by TE teachers. By achieving a consensus, a critical list of biotechnology competencies was established that should be included in teacher education programs. Further development of these competencies may lead to more inclusion and development of a curriculum to prepare teachers to include biotechnology in secondary classrooms.

Conclusions

The Web-based modified Delphi technique applied to this research was an effective method of obtaining data from a diverse group of panel members widely separated by distance and may be useful in future studies establishing content in other TE core areas. The panelists reached consensus on 45 critical biotechnology competencies under eight content organizers that they felt should be acquired by secondary TE teachers to prepare them to include selected biotechnology content in their classrooms. They include Biotechnology Fundamentals, Bioethics, Environment, Bioengineering, Agriculture, Medicine, Industry, and Bioinformatics. The initial list of biotechnology competencies identified through the extensive literature review was consistent with the validated list produced by the Delphi panelists as representing those that should be possessed by first-year/initially certified secondary TE teachers. The literature reviewed and data produced by this study substantiated the need to include biotechnology in technology teacher education programs to facilitate student learning of the benchmarks for grades 9-12 identified by ITEA Standard 15.

Recommendations

1. Revisions should be made to preservice technology teacher education programs so that graduates are competent to deliver the 45 critical biotechnology competencies established and validated by this research. By inference, teacher inservice programs may also need to be modified.
2. Further research into the current state of preparedness of secondary TE teachers to deliver the 45 competencies identified and validated by this research should be conducted.
3. Due to the blend of science and technology encompassed in the biotechnology competencies identified by the cross-disciplined Delphi panel, it is recommended that traditional "isolationist" models of instruction be revised at both the secondary and university teacher education levels in favor of a collaborative teaching strategy.
4. The competencies identified by this research may represent a potential starting point for including biotechnology content in teacher education programs on an international level. These competencies should continue to be further refined through discussion and debate.
5. Further research should be conducted regarding the feasibility and extent of biotechnology content that can be included within technology teacher education programs.
6. A biotechnology curriculum guide based on the identified competencies should be developed to facilitate the inclusion of biotechnology into technology teacher education programs.
7. This study should be replicated using a ranking method focused on developing quantitative data to further validate the critical biotechnology competencies identified.

References

California State University Program for Education and Research in Biotechnology (2001). *The current and future workforce needs of California's biotechnology industry: A study and summary of public hearings*. Retrieved August 22, 2003, from http://www.csuchico.edu/csuperb/WkFcSurvResults_CA_Needs.html

Clayton, M. J. (1997). Delphi: A technique to harness expert opinion for critical decision-making tasks in education. *Educational Psychology, 17*(4), 373-386.

Custer, R. L., Scarcella, J. A., & Stewart, B. R. (1999). The modified Delphi technique: A rotational modification. *Journal of Vocational and Technical Education, 15*(2), 50-58.

De Miranda, M. A. (2004). Ethical issues in biotechnology. In R. B. Hill (Ed.) *Council on Technology Teacher Education Yearbook: Vol. 53. Ethics for Citizenship in a Technological World* (pp. 60-81). Peoria, IL: Glencoe/McGraw Hill.

Dunham, T., Wells, J., & White, K. (2002). Biotechnology education: A multiple instructional strategies approach. *Journal of Technology Education 14*(1), 65-78.

Finch, C. R., & Crunkilton, J. R. (5th ed.). (1999). *Curriculum development in vocational and technical education.* Needham Heights, MA: Allyn and Bacon.

International Technology Education Association. (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

Isaac, S., & Michael, W. B. (1981). *Handbook in research and evaluation* (2nd ed.). San Diego, CA: EDITS.

Rogers, G. E. (1996). The technical content of industrial/technology teacher education. *Journal of Technology Education*, *8*(1), 40-49.

Russell, J. (2003). The assessment of student learning is a pivotal component of effective teaching and learning. *The Technology Teacher, 63*(2), 28-32.

Sharp, D., Liebenau, A., Stocks, N., Bennewith, O., Evans, M., Jones, W. B. et al. (2003). Locally developed guidelines for the aftercare of deliberate self-harm patients in general practice. *Primary Healthcare Research and Development, 4*(1), 21-28.

Walker, J. P., & Echternacht, L. (1992), *Desktop competencies needed in a business world.* Paper presented at the Delta Pi Epsilon National Research Conference, Los Angeles, California.

Wells, J. G. (1994). Establishing a taxonometric structure for the study of biotechnology in secondary school technology education. *Journal of Technology Education*, *6*(1), 58-75.

Student Perceptions of Selected Technology Student Association Activities

Jerianne S. Taylor

Background and Rationale

Student Organizations

Since the early 1950s, career and technical student organizations (CTSOs) have provided co-curricular activities for career and technical education students in grades 6-12. Currently, ten career and technical organizations are available for students in agriculture, business, family and consumer science, health occupations, marketing, technology education, and trade and industry programs. Each of the CTSOs is recognized by the United States Department of Education as being an integral part of the respective discipline's curriculum (United States Department of Education, 1998). "CTSOs provide a unique mix of instructional programs and activities that provide middle, junior high, secondary, postsecondary, adult, and collegiate students with opportunities for leadership and career development, motivation to learn and achieve, and recognition for effort and progress (Scott & Sarrkees-Wircenski, 2001, p. 265). The opportunities provided by CTSO activities support many learning theories such as constructivism, inquiry based learning, and cooperative learning, to name a few.

The Technology Student Association

The Technology Student Association (TSA), one of ten CTSOs, is the only student organization dedicated exclusively to students enrolled in technology education classes in grades K-12. TSA serves more than 160,000 K-12 students in 2,000 schools in 47 states nationwide. The majority of TSA's membership consists of middle and high school students (Technology Student Association, 2001a). Its mission is to prepare the membership for the challenges of a dynamic world by promoting technological literacy, leadership, and problem solving, resulting in personal growth and opportunity (TSA, 2001b). TSA provides technology education students with the opportunity to develop leadership and problem solving skills through various avenues including student competitions at

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the local, state, and national level. Currently, TSA offers more than 50 middle and high school competitive events representing most areas of technology education, the *Standards for Technological Literacy*, and various leadership skills.

TSA's Educational Value. The effect that TSA has on a student member is often difficult to document. It is only through direct interaction with the student that one is able to record these effects; this in turn limits the amount of research related to the area. Many of the effects and potential effects of TSA often emerge through the study of other areas related to technology education.

The effects of TSA can be noted in the research in areas including program quality, problem-solving, and critical thinking skills. Busby (1999) reported in his study that used Clark's quality indicators for technology education programs in North Carolina (1997), that the only quality indicator for which there was a significant difference between low performing schools and high performing schools was the program's involvement in TSA**.** High performing and low performing schools were defined by the schools overall score on the North Carolina VoCATs test.

Trainer (1996) researched the potential of the national TSA curricular activities to promote student creative problem-solving and critical thinking skills. Her study concluded that all four TSA activities selected for the study were identified as promoting thinking skills. The results of her research also suggested that all of the teachers believed that the activity they evaluated had the potential to promote creative problem-solving and critical thinking skills among students.

According to the promotional materials developed by TSA, the organization's activities can have an effect upon the attitudes, growth, and development of each member. The *TSA Chapter Startup Kit* lists some of the benefits students derive from TSA such as learning from leadership training; developing and increasing individual civic pride, responsibility, and involvement; the opportunity for individual growth, development, and maturation according to one's own interests and abilities; opportunity to gain additional career information and exposure; opportunity to participate in local, state, and national conferences; learning how to share with others; etc. (TSA, 2000, p. 1.9). Although many of the effects are not backed by research studies, they represent the self-perceptions of the Association about its effects. The assumptions made by teachers, state supervisors, and TSA about the effects of participation allow one to ask, is this really how the student members perceive the organization? The statements also provide a premise for studies related to the perception of the TSA and the validity of such assumptions in regards to the student membership's perception of their student organization.

TSA and Standards for Technological Literacy. Technological literacy is defined as the ability to use, manage, understand, and assess technology as represented by standards and benchmarks in the document (ITEA, 2000, p. 242). According to the National Academy of Engineers and the National Research Council, technological literacy encompasses three interdependent dimensions: (1) knowledge; (2) ways of thinking and acting; and (3) capabilities (2002).

Several technology education professionals have identified the contributions of TSA and its relationship to on technological literacy as defined by the Standards for Technological Literacy. According to Wright (2000), "Although STL [Standards for Technological Literacy] is not intended to be a curriculum, it provides the content for what every student should know and be able to in order to be technologically literate. The TSA competitive events complement the twenty standards and are related to the benchmarks" (p. 7). Dugger (2001) added, "TSA has an important role to play in this implementation effort [referring to the Standards for Technological Literacy] (p.7). More recently, Willcox (2003) stated,

> TSA can make a significant contribution toward assisting every student in grades K-12 to become technologically literate by developing cocurricular competitive events that required students to demonstrate their abilities to use, manage, assess, and understand technology. Because of such experiences, student will be able to show evidence of their knowledge and ability to solve simplistic and complex technology-based problems. Students' solutions to such problems/challenges will include the application of mathematics, science, design, engineering, and technology. (p. 7)

Based on the previous studies, as well as affirmations and comments from various professionals, the researcher realized the potential role and perceived roles that TSA can play in developing today's youth. This study provided foundational data to document the beliefs of these professionals by looking at the perceptions of TSA student members. Without such information, TSA is open to criticism and skepticism in regards to its claims about the benefits of membership.

The TECH-know Project

The TECH-know Project is an instructional materials development effort funded by the National Science Foundation (NSF # 0095726) and centered at North Carolina State University. The four year project started in August 2001 with the primary purpose of developing standards-based instructional materials for twenty TSA activities. The TECH-know project represents a significant collaboration between selected state departments, universities, businesses, and TSA. From 2001-2004, more than 140 technology education teachers, technology teacher educators, TSA Curriculum Resource Committee members, and business representatives from across the country, worked together to attempt to develop high quality, standards-based units of instruction based on the *Standards for Technological Literacy, National Science Education Standards, Principles and Standards for School Mathematics*, and TSA activities.

Purpose of the Study

The purpose of this study was to analyze the perceptions of TSA members about selected TSA activities in regard to their effects on skill development and the development of technological literacy. Self-reported measures were designed to assess the effect of the selected activities. These measures examined students' involvement in and preparation for the activity, as well as how this involvement and preparation affected skill development and understandings related to the *Standards for Technological Literacy*. The measures were derived from the *Standards for Technological Literacy*, a review of literature, and the TECH-know Leadership Team.

Method

A survey instrument, *Student Perception of Selected TSA Competitive Events*, developed in 2001 by the TECH-know Project for inquiry and evaluation of its materials and their relationship to TSA, was modified and used as the primary instrument for gathering data related to three research questions.

Research Questions

5. What are the perceptions of the participants regarding their skill development and understandings related to technological literacy?
6. Are there any associations between the participants' involvement in TSA and their perception of skill development and understandings related to technological literacy?
7. Does involvement in selected TSA activities affect one's perception of skill development and understandings related to technological literacy?

The TSA activities included in the study were selected based on their representation and implementation in the TECH-know Project, as well as their perceived ability to reflect all areas of the *Standards for Technological Literacy*. They included the following:

High School Level Activities	**Middle School Level Activities**
Agriculture and Biotechnology Design	Agriculture and Biotechnology Challenge
Desktop Publishing	Cyberspace Pursuit
Film Technology	Digital Photography
Manufacturing Prototype	Dragster Design Challenge
Medical Technology Design	Environmental Challenge
R C Transportation	Flight Challenge
Sci Vis	Mechanical Challenge
Structural Engineering	Medical Technology Challenge
System Control	Structural Challenge
Technology Challenge	Transportation Challenge

The target population for the study consisted of all participants registered for competitive events related to the selected activities at the 2003 National TSA Conference in Orlando, Florida. The number of registrants was obtained from the TSA national office in Reston, Virginia prior to the conference. The sample consisted of those registered participants who checked in for the competition and returned the survey to the Competitive Event Coordinator. The surveys were distributed by TSA to the Competitive Event Coordinators at the 2003 National TSA Conference in Orlando, Florida and then returned to the TECH-know Project for analysis.

Instrument Development

According to Gall, Borg, and Gall (1996), "questionnaires and interviews are used extensively in educational research to collect information that is not directly observable" (p. 289). "Questionnaires have two advantages over interviews for collecting research data: The cost of sampling respondents over a wide geographic area is lower, and the time required to collect the data typically is much less" (Gall, Borg, and Gall, 1996, p. 289). This advantage enabled the researcher to collect the opinion of more than 1100 TSA participants in less than a week at a reasonable expense.

Thomas (2003) noted that surveys are useful for revealing the current status of a target variable within a particular entity. He stated that "the accuracy of the description is enhanced if the variable is expressed in numerical form (frequency, percents, correlation coefficients, etc.) than if the results are reported by means of imprecise verbal expression" (Thomas, 2003, p. 44). Thomas also noted, however, that the numerical presentations of data "fail to describe the qualitative features that make for the uniqueness of each member of collectivity that the survey intended to represent" and is a limitation to the survey approach (Thomas, 2003, p. 44). This argument caused the researcher to employ a mixed quantitative-qualitative methodology which is not discussed in this article due to size limits but focuses on the use of two open ended questions on the survey instrument and TECH-know's student reflection writings to provide triangulation and elaborate on the findings associated with survey data.

The survey instrument titled *Student Perception of Selected TSA Competitive Events,* mentioned earlier, was divided into four sections. Part One gathered background information related to the participants and was developed based on the research and curricular needs of the TECH-know project. This section provided the researcher with an indication of the participants' involvement in TSA and thus was a measure of the independent variables in the study.

Part Two of the instrument measured the students' perceptions of the skills they developed relative to technological literacy. The variables measured were based on the review of literature that included *Technology Student Associations*, the 38th Yearbook of the Council on Technology Teacher Education *(1989), the TSA Chapter Startup Kit,* and the opinions of the TECH-know staff and a panel of experts who reviewed the survey.

Part Three of the instrument focused on the participants' perceptions about their understanding of technological literacy as defined by the *Standards for Technological Literacy.*

Part Four of the instrument focused on the participants' involvement in the activities of the Conference and their perceptions of how their involvement contributed to their academic and personal development. Perceptions were measured using a Likert-type scale consisting of strongly agree, agree, undecided, disagree, and strongly disagree. Two open-ended questions allowed participants to provide additional insights not included in the structured questions.

Pilot Study

To insure validity and reliability, two pilot studies were conducted: one at the state level and one at the national level. The sample for the first pilot study consisted of the participants involved in the twenty selected TSA activities at the 2002 North Carolina Technology Student Association Spring Conference. This conference was chosen because of its size, its location, and the researcher's prior association with it. The second pilot study involved the participants involved in the 2002 Technology Student Association National Conference. This conference was chosen because of its similarity to the actual population involved in the full study.

The instrument was revised as a result of the pilot studies, the input of the TECH-know project staff, and the panel of experts. Most of the procedures used in the pilot study were used in the actual study. However, to ensure a more accurate response set, instruments were distributed to each individual involved in the selected TSA activities rather than to each team, as was done in the first two pilot studies. In addition, in the actual study a cover letter was included to clarify the purpose of the investigation to the participants.

Findings

Data Analysis

Both descriptive and inferential statistics were used to analyze the data from the respondents to the *Student Perception of Selected TSA Competitive Events* instrument. Frequency distributions were used to describe the overall attitudes of the respondents. Pearson's chi-square was then used to determine if there were any associations between respondents' involvement in the TSA activity and their perceptions. Since the data were significantly skewed, the categories of undecided, disagree, and strongly disagree were combined to establish an n greater than 5, enabling Pearson's chi-square to be used. This decision was made based upon the advice of the researcher's advisory committee. A critical value of 18.75 with an alpha of 0.05 was determined appropriate given the size of the study.

The respondents represented both genders, as well as middle and high school level students. Instruments were received from participants for nineteen of the twenty TSA activities, yielding an overall response of 42%. The responses for the individual contests ranged from 0 to 79%.

Average Time Spent in Class Preparing for the Activity

The participants chose one of six different time ranges that best reflected the amount of time they spent preparing for the TSA activity. The data varied for this question relative to the activities. For example, Structural Challenge is an on-site competition where two students build a bridge or tower in a specified amount of time, while Environmental Challenge is more of a community service related competition that requires student to solve and implement an environmental problem of local interest. Given the age of the respondents, time allotments were utilized for this response in the actual study when the pilot study revealed the data were inflated. A category of "none" was also added to accommodate for on-site TSA activities.

Fourteen percent of the participants spent more than 40 hours in class preparing for an activity. Four percent spent between 31 to 40 hours and eight percent spent 21 to 30 hours preparing. Thirty-six percent of the participants spent 1 to 10 hours preparing, while twenty-one percent of the participants did not spend any time in class preparing. Less than two percent did not respond to this question.

Understandings Related to the Standards for Technological Literacy

A series of 12 statements were presented to the participants in order to gain an understanding of what they felt they were learning relative to *Standards for Technological Literacy*. The majority agreed that being involved in their selected activity did increase their understanding of what technology is and how technology works, as defined by these questions (See Table 1). Table 1 also reports that the participants perceived their involvement in the activity increased their understanding of the effects of technology on society and how to solve technology-related problems. Participants perceived that they increased their understanding of how to use the design process and how to solve technology-related problems as a result of being involved in these selected TSA activities.

Participants in the Medical Technology activity felt they increased their understanding the most when compared to participants in other high school level activities regarding what technology is, how technology works, and the effects of technology on society. One could argue that this is due to the investigative nature of the activity and its challenge to the students – "choose a contemporary problem related to medical technology and demonstrate understanding through research, development of a solution, and an effective multimedia presentation" (TSA, 2004, p. 123). Many of the high school level activities utilize design and problem solving techniques as a primary method, thereby

Table 1
Extent of agreement to statements regarding the development of understandings related to the Standards for Technological Literacy.

Statement (*n* = 1138)	**Strongly Agree** % (n)	**Agree** % (n)	**Undecided** % (n)	**Disagree** % (n)	**Strongly Disagree** % (n)	**No Response** n
What technology is	31.8 (358)	41.3 (466)	18.6 (210)	6.7 (75)	1.6 (18)	11
How technology works	35.8 (402)	44.3 (498)	13.8 (155)	4.6 (52)	1.4 (16)	15
The effect of technology on society	41.8 (469)	34.6 (388)	17.3 (194)	4.5 (51)	1.9 (21)	15
How to use the Design Process	45.0 (505)	37.5 (421)	13.4 (150)	2.8 (31)	1.3 (15)	15
How to solve technology related problems	40.6 (455)	41.2 (461)	14.6 (164)	2.9 (33)	0.7 (7)	18

explaining the higher response for the questions related to the participants' perception of increasing their understanding of how to use the design process and solve technology-related problems.

Environmental Challenge participants thought that their challenge of developing a plan then solving an environmental problem of local concern allowed them the opportunity to solve a technology-related problem as well as learning what technology is and how it works. Agriculture and Biotechnology Challenge participants perceived that they increased their understanding of the effects of technology on society as they researched and created displays related to areas of interest in agriculture and biotechnology.

Skill Development

Part Two of the survey addressed the participants' perception of skill development as it pertained to the TSA activity in which they were involved. Table 2 highlights the participants' perception of the skills they developed while participating in the TSA activity. The vast majority of the participants felt that they developed problem solving skills (88.4%) and skills related to learning more about technology. A large proportion (83.2%) felt that they developed teamwork skills while preparing for the TSA activity. Approximately three fourths of the participants felt they developed leadership (76.3%) and math skills (75.7%) while preparing for activities in which they participated. Nearly this proportion (72.2%) felt that they developed science skills while preparing for the activity. Table 2 also shows that nearly all of the participants felt that they developed skills related to working within rules and specifications (93.4%), developed design skills (92.3%), allowed them to be creative (91.9%) and work with their hands (91%). Most (81.6%) believed they developed communication skills while participating in their chosen activity.

Table 2
Extent of agreement to statements regarding the development of skill while participating in the TSA activity.

Statement (*n* = 1138)	**Strongly Agree** % (n)	**Agree** % (n)	**Undecided** % (n)	**Disagree** % (n)	**Strongly Disagree** % (n)	**No Response** % n
Problem Solving	42.6 (481)	45.8(5 17)	9.0 (102)	1.7 (19)	0 (11)	8
Teamwork	51.1 (577)	32.1 (363)	10.1 (114)	3.6 (41)	3.1 (35)	8
Leadership	37.5 (422)	38.8 (436)	16.4 (184)	4.8 (55)	2.5 (28)	13
Ability to use science	34 (385)	38.2 (432)	19.8 (224)	6.2 (70)	1.9 (21)	6
Ability to use math	37.8 (426)	37.9 (427)	15.5 (174)	6.3 (71)	2.5 (28)	12
Ability to learn more about technology	53.4 (600)	35.3 (397)	8.7 (98)	1.7 (19)	0.0 (10)	14
Hands-on Skills	61.0 (687)	30.0 (338)	7.1 (80)	1.2 (14)	0.7 (8)	11
Work within rules and specifications	62.8 (708)	30.6 (345)	5.3 (60)	1 (11)	0.0 (4)	10
Communication Skills	43.7 (493)	37.9 (428)	14.0 (158)	2.7 (31)	1.7 (19)	9
Ability to design	63.8 (720)	28.5 (322)	6.3 (71)	0.9 (10)	0.0 (5)	8
Ability to be creative	65.8 (741)	26.1 (294)	5.8 (65)	1.2 (14)	1.1 (12)	12

General

Part Four of the survey addressed additional areas of interest to the TECH-know project and reviewers. It also highlighted some areas of interest in the research regarding motivation, integration, and career awareness. Nearly 90 percent of the participants believed being involved in the TSA activity motivated them to do their best work. Seventy-two percent of the participants felt that being involved in the TSA activity helped them in their technology class and that it would also help them in their future career. Finally, approximately half of the participants saw the connection to the TSA activities and their mathematics and science classes. Table 3 summarizes the responses.

Table 3
Extent of agreement to general statements relative to participating in the in the TSA activity.

Statement (n = 1138)	**Strongly Agree** % (n)	**Agree** % (n)	**Undecided** % (n)	**Disagree** % (n)	**Strongly Disagree** % (n)	**No Response** % n
Motivated to do my best work	55.9 (609)	31.6 (344)	0.8 (92)	2.2 (24)	1.8 (20)	49
Helped me in technology class	37.9 (415)	34.1(3 74)	18.2 (200)	6.3 (69)	3.5 (38)	42
Helped me in science class	27.2(2 98)	28.8 (315)	25.1 (275)	13.8 (151)	5.0 (55)	40
Helped me in math class	21.1 (231)	26.8 (293)	27.6 (302)	17.8 (195)	6.7 (73)	40
Will help me in my future career choice	43.6 (476)	28.1 (307)	20.0 (218)	4.5 (49)	3.8 (42)	46

Part Three of the survey compared the select ITEA/Gallup Poll responses to the TSA participants, but was omitted from this article due to size limitations. It is important to note that even though these descriptive findings shed a positive light on the perceptions of this group of respondents, not all participants agreed to every statement. Factors that could have affected their attitudes include, but are not limited to the requirements and purpose of the TSA activity, time that participant worked on the TSA activity, and/or wording of the question.

Inferential Analysis

In order to address the second research question regarding the associations between the participants' involvement in TSA and their perceptions of skill development and understandings related to technological literacy, Pearson's chi square was utilized. The Pearson's chi-square test compared the observed frequencies in the cells of a contingency table with the values expected from the null hypothesis of independence – H_o: Involvement in the TSA activity has no effect on the student's perception of skill development or understandings related to technology literacy.

According to Agresti and Finlay, "The larger the χ^2 value, the greater the evidence against the null hypothesis test for independence" (Agresti & Finlay, 1997, pg. 255). Since the data were skewed, the first 3 cells (strongly disagree, disagree, and undecided) were combined to assure that the resultant single cell would have an n greater than 5.As noted earlier, an alpha of .05 was established to denote statistical significance. With the six time allotment categories and three categories for participants' perceptions, a critical value of 18.31 was determined by referring to chi-square distribution values for various right-tail probabilities in Agresti & Finlay, 1997, pg. 670. JMP 5 was utilized to compute the Pearson chi-square test for independence for each of the categories.

Twenty eight contingency tables were generated to represent each category in Parts 2, 3, and 4 of the survey by time spent preparing for the TSA activity in class and Pearson chi-square were computed. Significant associations were found for all categories. Table 4 summarizes these findings related to skill development, understandings related to the *Standards for Technological Literacy*, and selected general areas of interest.

Given the significant nature of each association, Bonferroni's test for multiple comparison was then utilized to determine if individual cells were significant. Bonferroni's multiple comparisons allowed the researcher to look within the cells for chi-squared test values that were significantly greater or less than the expected. A critical value of 10.83 and p- value equal to 0.001 was determined to be acceptable after referring to Table C (Agresti & Finlay, 1997) and consulting a statistician who advised the researcher. Twenty three cells were identified that had chi-squared values greater than the critical value therefore suggesting associations between the variables. These cells are summarized in Table 5. The columns are classified by the perception, followed by the category, then the time allotment. Plus and minus signs denote whether the observed frequency was higher or lower than the expected frequency, respectively. Observed frequencies were higher for all but three of the cells identified through Bonferroni's test for multiple comparisons. The cells identified through Bonferroni's approach suggested that those who spend no time preparing for the activity in class disagreed or were undecided in their responses to the various categories. Significant associations were also found between those who strongly agreed to the categories and spent 40+ hours in class preparing for the activities.

Since the associations were found in the corners of the contingency table, the researcher furthered her investigation by asking the third research question, does involvement in selected TSA activities affect one’s perception of skill development and understandings related to technological literacy? Logistic fit was utilized to determine whether one’s perception of skill development and understandings related to the *Standards for Technological Literacy* increased as the participants’ time spent preparing in class increased. The logistic fit was utilized only for the fifteen categories that where identified in Table 5 as significant through Bonferroni's test for multiple comparisons. The fifteen categories are identified in Table 5. For each of the categories, as the time spent in class preparing for the TSA activities increased; the percentage of participants to agree or strongly agree increased.

Table 4
Associations found between various categories and time spent in class.

Associations found between skills developed and time	(Critical Value > 18.31, df =10, alpha = 0.05)
Problem Solving	$X^2(10, N = 1110) = 40.50, p = .0001$
Teamwork	$X^2(10, N = 1110) = 27.18, p = .002$
Leadership	$X^2(10, N = 1107) = 30.85, p = .0006$
Ability to use science	$X^2(10, N = 1112) = 53.81, p = .0001$
Ability to use math	$X^2(10, N = 1106) = 53.82, p = .0001$
Ability to learn more about technology	$X^2(10, N = 1105) = 43.55, p = .0001$
Use of hands-on skills	$X^2(10, N = 1107) = 29.31, p = .001$
Work within rules and specifications	$X^2(10, N = 1108) = 33.65, p = .0002$
Use of communication skills	$X^2(10, N = 1110) = 23.82, p = .008$
Design skills	$X^2(10, N = 1108) = 25.12, p = .005$
Creativity and time spent in class	$X^2(10, N = 1106) = 22.67, p = .01$
Associations found between understandings and time	
What technology is	$X^2(10, N = 1107) = 59.19, p = .0001$
How technology works	$X^2(10, N = 1103) = 45.26, p = .0001$
The effect of technology on society	$X^2(10, N = 1103) = 35.60, p = .0001$
How to solve technology related problems	$X^2(10, N = 1110) = 55.12, p = .0001$
How to use the design process	$X^2(10, N = 1103) = 54.31, p = .0001$
Medical technology	$X^2(10, N = 1099) = 39.69, p = .0001$
Agricultural and Biotechnology	$X^2(10, N = 1092) = 45.12, p = .0001$
Energy and Power	$X^2(10, N = 1094) = 51.80, p = .0001$
Communication technology	$X^2(10, N = 1096) = 34.97, p = .0001$
Construction technology	$X^2(10, N = 1101) = 23.81, p = .0081$
Manufacturing technology	$X^2(10, N = 1097) = 29.41, p = .001$
Transportation technology	$X^2(10, N = 1093) = 51.27, p = .0001$
Associations found between general categories and time	
Helped in technology class	$X^2(10, N = 1080) = 109.97, p = .0001$
Helped in math class	$X^2(10, N = 1078) = 35.95, p = .0001$
Helped in science class	$X^2(10, N = 1079) = 44.13, p = .0001$
Will help in future career choice	$X^2(10, N = 1077) = 41.93, p = .0001$
Motivated me to do my best work	$X^2(10, N = 1074) = 37.80, p = .0001$

Table 5
Associations found through Bonferroni's test for multiple comparisons

Stem	Perception of Respondents	Time Spent In Class	Critical Value
Problem Solving	Strongly Agree	40+ hrs. +	$X^2(1, N = 106) = 14.76, p = .0001.$
Ability to use Math Skills	Strongly Agree	40+ hrs. +	$X^2(1, N = 94) = 12.19, p = .0001.$
Use of Hands-on Skills	Disagree and Undecided	None -	$X^2(1, N = 37) = 12.22, p = .0001.$
Work within Rules and Specifications	Agree	40+ hrs. +	$X^2(1, N = 27) = 12.82, p = .0001.$
Use of Communication Skills	Strongly Agree	40+ hrs. +	$X^2(1, N = 97) = 21.25, p = .0001.$
What technology is	Disagree and Undecided	None+	$X^2(1, N = 92) = 12.30, p = .0001.$
What technology is	Strongly Agree	40+ hrs. +	$X^2(1, N = 80) = 11.71, p = .0001.$
How technology works	Disagree and Undecided	None +	$X^2(1, N = 71) = 12.79, p = .0001.$
How technology works	Strongly Agree	40+ hrs. +	$X^2(1, N = 90) = 12.18, p = .0001.$
The Effect of Technology on Society	Disagree and Undecided	None +	$X^2(1, N = 81) = 11.01, p = .0001.$
How to solve a technology-related problem	Disagree and Undecided	None+	$X^2(1, N = 69) = 15.41, p = .0001.$
How to solve a technology-related problem	Strongly Agree	40+ hrs. +	$X^2(1, N = 102) = 13.95, p = .0001.$
How to use the Design Process	Disagree and Undecided	None+	$X^2(1, N = 66) = 13.60, p = .0001.$
How to use the Design Process	Strongly Agree	40+ hrs. +	$X^2(1, N = 109) = 12.07, p = .0001.$
Energy and Power Technology	Strongly Agree	40+ hrs. +	$X^2(1, N = 67) = 16.05, p = .0001.$
Communication Technology	Strongly Agree	40+ hrs. +	$X^2(1, N = 67) = 13.17, p = .0001.$

Note: Plus and minus signs in the third column denote whether the observed frequency was higher or lower than the expected frequency.

Table 5 *(continued)*
Associations found through Bonferroni's test for multiple comparisons

Stem	Perception of Respondents	Time Spent In Class	Critical Value
Transportation Technology	Strongly Agree	40+ hrs. +	$X^2(1, N = 76) = 18.06, p = .0001.$
Helped me in Technology class	Disagree and Undecided	None +	$X^2(1, N = 120) = 45.36, p = .0001.$
Helped me in Technology class	Disagree and Undecided	40+ hrs. -	$X^2(1, N = 54) = 13.90, p = .0001.$
Helped me in technology class	Strongly Agree	None -	$X^2(1, N = 19) = 16.53, p = .0001.$
Will help with my future career	Disagree and Undecided	None +	$X^2(1, N = 95) = 12.46, p = .0001.$

Note: Plus and minus signs in the third column denote whether the observed frequency was higher or lower than the expected frequency.

Discussion

Although the results of this study are only reflective of the participants at the 2003 TSA National Conference, they do shed light on the fact that TSA is valued and using TSA activities in the classroom added value to their perception of learning, both in and out of class. The study showed that the more time the participants spent in class preparing for the activities, the more likely they were to have positive perceptions about what they learned from the TSA activities and skills they developed in other areas. The study offers insight to teachers that the use of TSA activities in the classroom benefits students beyond the opportunities to participate in out-of-school competitive events. However, further research is needed to show in detail what is actually learned through the use of these activities both in class and out.

The data showed that most participants felt the activities motivated them to do their best work, helped them in their technology classes, and would help them in their future careers. Approximately half of the participants felt the activity in which they were involved helped them in their mathematics and science classes. Enabling students to become motivated and do their best work provides the opportunity for success in many areas, directly and indirectly. Teachers need to capitalize on these motivational effects. Just how the technology education profession decides to best utilize the opportunities that involvement in TSA provides is open to discussion and further development.

The descriptive data and associations found in this study provide a baseline for further studies related to the effects of TSA activities on skill development, cognitive knowledge, and career choice. The data also provide insights related to the student members and their perception of the organization and its0 potential to encourage the integration of math, science, and technology.

The data generated by this study, based on participants in the 2003 TSA competitive events, provide a base line for further investigations at the local, state, and national levels. The research provides foundational evidence to support the benefits of participation in the Technology Student Association and how it has the potential to enhance the intellectual, technological, and social development of students. Through replication of this study, the door is open to longitudinal studies in the future, something that could not have been done previously. Case studies and additional qualitative research are recommended to give additional depth and meaning. Finally, this study enables comparisons to be made among other career and technical student organizations and in other settings.

Conclusion

Developing technological literacy in today's youth through organizations like TSA offers great potential. It is important to recognize the roles that these organizations play in developing young people. Organizations like TSA should continue to step up to the challenge by documenting and reporting the student successes and the cognitive knowledge gained through involvement in their activities. These organizations should also be recognized for the contributions they provide to many young people. Sincere appreciation is extended the Technology Student Association and the TECH-know project for their willingness to initiate the challenge.

References

Agresti, A., & Finlay, B. (1997). *Statistical methods for the social sciences* (3rd edition). Upper Saddle River, NJ: Prentice Hall, Inc.

Betts R. & Van Dyke A.W. (Eds.). (1989) *Technology Student Associations.* Mission Hills, CA: Glencoe.

Busby, J. (1999). *Measuring Clark's quality characteristics for technology education for a relationship with student achievement.* Unpublished doctoral dissertation, North Carolina State University, Raleigh, NC.

Clark, A. C. (1997). *Identification of quality characteristics for technology education programs in North Carolina.* Unpublished doctoral dissertation, North Carolina State University, Raleigh, NC.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Dugger, W. E. (2001). Standards Correlation. In Technology Student Association (Eds.), *Middle school technology activities: The official TSA competitive events guide 2002-2003*. Reston, VA: Author

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction* (6th edition.). White Plains, NY: Longman Publishers.

International Technology Education Association (1996). *Technology for all Americans: A rationale and structure for the study of technology*. Reston, VA: Author.

International Technology Education Association (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: Author.

International Technology Education Association (2003). *Advancing excellence in technological literacy: Student assessment, professional development, and program standards*. Reston, VA: Author.

Lewis, T. (1999). Research in technology education – Some areas of need. *Journal of Technology Education, 10*(2), 41-56.

Loepp, F. (1989). Why student organizations? In M. Betts & A. Van Dyke (Eds.), *Technology student organizations* (pp. 3-14). Mission Hills, CA: Glencoe.

National Academy of Engineers & National Research Council (2002). *Technically speaking*. Washington, D.C: National Research Council.

North Carolina Department of Public Instruction (2003). *Career and technical student organization*. Retrieved June 12, 2003, from http://www.ncpublicschools.org/workforce_development/vso/

Peterson, R. E. (2001). *TECH-know* [Brochure]. Raleigh: North Carolina State University.

Scott, J. & M. Sarrkees-Wircenski (2001). *Overview of Career and Technical Education*. (2nd edition). Homewood, IL: American Technical Publishers.

Taylor, J. S. (2004). *An analysis of the variables that affect technological literacy as related to selected Technology Student Association activities.* Unpublished doctoral dissertation, North Carolina State University.

Technology Student Association (2000). *The TSA chapter startup kit*. Reston, VA: The author.

Technology Student Association (2001). *About TSA*. Retrieved January 18, 2003, from http://www.tsaweb.org/about/.

Technology Student Association (2001). *Mission of TSA*. Retrieved January 18, 2003, from http://www.tsaweb.org/about/mission.html .

Thomas, R. M. (2003). *Blending qualitative and quantitative research methods in theses and dissertations.* Thousand Oaks, CA: Sage Publications.

Willcox, G. (2003). Standards Correlation. In Technology Student Association (Ed.), *Middle school technology activities: The official TSA competitive events guide 2004-2005*. Reston, VA: Editor.

Wright, M. (2002). Standards Correlation. In Technology Student Association (Ed.), *Middle school technology activities: The official TSA competitive events guide 2003-2004*. Reston, VA: Editor.

Editorial

Is Design a Right-Brain or Left-Brain Activity?

Joseph McCade

Are we defining design too narrowly? Could it be that our own definition of technology is closely tied to our personal leaning style? Welby Ings (2005) challenged us to consider the critical role of creativity in design. The National Science Foundation has done much to encourage a somewhat different approach to design. From this perspective a strong case is made for the integral role of mathematics as a component of design.

I have long believed that design is a hinge pin component of doing technology. Design is the process by which those engaged in technology produce systems, products, and methods, just as inquiry is the process by which those doing science produce new knowledge about the natural world. There are at least two groups who consider design their primary purpose: industrial designers and engineers. While the two groups do not seem equally represented in the technology education profession, they are both represented enough to keep me thinking about the nature of design.

Ings (2005) is passionate about learners and technology. He is well recognized as an innovative educator (New Zealand Qualification Authority, 2002). As a former classroom teacher, I felt particularly connected to his efforts in helping students who had limited success in school find at least one place to shine. He illustrated with several examples his commitment to help those students who "do not serve the gods of literacy and numeracy" excel in the world of creative design. While he used the phrase "gods," I feel he probably means "idols." In fact, a central concept in his presentation, "trading beyond experience," suggested something about the essential role of creativity in design. He illustrated this concept with a story about one of his former students who created an amazing animated tree for the movie *Lord of the Rings*. As one might imagine, the kind of out-of-the-box thinking needed to bring such an idea to life did not make it easy for this student to fit in with the rest of the students in the

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school or its structure. I found Ing's argument that schools should be places that value students whose gifts may not fit the math and language paradigm quite compelling.

Quite a different approach to design is illustrated by the concept of "informed design." This is the product of several National Science Foundation grants, and is well represented in the New York State Curriculum for Advanced Technology Education (NYSCATE). The project is co-directed by M. David Burghardt and Michael Hacker of Hofstra University. Their definition of technological design is (2006):

> … a planned process of making design choices and trade-offs within given constraints, which leads to the development of a product, process, or system that satisfies human needs or wants. Technological design is a multidisciplinary problem-solving process involving the synthesis of many areas of knowledge and skills including technical, scientific, mathematical, societal, ethical, environmental, aesthetic and linguistic.

The example activities found on the NYSCATE Website include the careful development of knowledge and skill in prerequisite areas before the design process is used to solve a problem. Thus the idea is that design is "informed" as opposed to being the result of a guess or multiple guesses. Hacker and Burghardt value mathematics at least in part because of its frequent use in predicting the outcomes of technological endeavors. The problem of decreasing emphasis on mathematics in preparing pre-service technology teachers was puzzling to Burghardt and Hacker since the link between science, mathematics, and design was quite obvious.

I thought I had these somewhat divergent constructs concerning design neatly divided into two camps: engineering design in which mathematics and science are the cornerstones on the one hand, and industrial design in which creativity and aesthetics are cornerstones on the other. Ings threw a twist into my thinking when he pointed out that Einstein came up with the theory of relativity by imagining himself "riding on a ray of light." I was beginning to better understand the idea of "trading beyond experience." This kind of creativity can be important in solving technological problems as well as scientific and artistic challenges. Of course, the fact that Einstein expressed his theory as a mathematical formula ($E=MC^2$) just challenged my thinking a bit more. I was approaching my previous assumption (that design involves a continuum and invention is more aligned with creativity, while innovation is more aligned with mathematics and science) with growing suspicion.

In the past I wondered if individuals with a predominately left-brain cognitive style are more likely to see design as an engineering process, based upon a strong understanding of science and math. Their abilities with words, logic, and analytical thinking seem to predict that they would. Conversely, I theorize that those who see design primarily as a creative activity probably have a predominately right-brain cognitive style. Their understanding of the whole picture along with abilities in art, visual-spatial thinking, and/or visual-motor activities would seem to serve them well in creative endeavors (Connell, 2006). If thinking about Einstein confuses my neat little science and math versus art and creativity world, then considering Leonardo da Vinci just plain gives me a headache.

I was also reminded of an experience I had several years ago in what was called a “pedagogy seminar.” I was teamed up with an English professor whose specialty was the interpretation of films. Students who were taking his film course and who were education majors could also take this seminar that used his film course as a case study. The English professor and I taught the seminar together. One early seminar session was spent on learning styles. We all took a learning styles inventory which divided our group across four major characteristics. These characteristics translated to quadrants on a graph. He and I were the most divergent outliers when we graphed the results. By the end of the course I had all but forgotten the learning styles inventory and I asked the English professor which student he thought was the best student in the seminar class. I was shocked when he identified the student I considered to be the lowest achiever in the group. Correspondingly, when he asked me who I thought the best student was, he was shocked since my choice was also the student he considered the worst in the class. After a few days I began to wonder if, as instructors, our assessment of students’ contributions and accomplishments might be related to learning styles. When I looked at the graph once again, the best student each of us selected was the person with the learning style closest to our own. I have always been quite comfortable with mathematics and science; consequently, it is easier for me to relate to design as an engineering endeavor than a creative endeavor.

There is not much representation in the *Standards for Technological Literacy* of the “creatively” oriented aspects of design. I think that this is a mistake, even though I feel ill prepared to guide students in these more creative activities. Not only is the aesthetic aspect of design important, the solution to several important technological problems grows out of a form of creativity not well represented by the working definition created by the standards. Logically, it seems that design is both a left-brained and a right-brained activity. Einstein and da Vinci offer proof of that. I am concerned about how to provide fair coverage and weight to such ideas as diverse as “informed design” and “trading beyond experience.” Trial and error as a process is valued by one learning style another vilifies it. One group values mathematical skills as essential while the other considers them as idols. I can see that those who build bridges see design differently than those who create motion pictures. Yet, I still scratch my head when I think about how to teach design. I still offer the “informed design” website from NYSCATE as an excellent resource to my student teachers. While I feel the site is a good resource to aspiring teachers, I fear I am still repeating the mistake I made when assessing the pedagogy seminar students by defining design according to my own experience – i.e., engineering. I know I should broaden my perspective and provide some tools to help these pre-service teachers encourage creativity and value the aesthetic aspects of design. The creative aspect of even the least artistically-oriented design often involves the imagination of the designer in ways I have yet to adequately value or model.

References

Connell, D. (2006). Left brain/right brain: Pathways to reach every learner. *Scholastic.* Retrieved February 20, 2006, from http://teacher.scholastic.com/products/instructor/brain.htm

Ings, W. (2005, April). *re think*. Keynote Presentation to the Annual Conference of the International Technology Education Association, Kansas City Missouri. Retrieved February 13, 2006, from http://www.iteaconnect.org/editorpage/2005/April/rethink.pdf

New York State Center for Advanced Technology Education. (2006). NYSCATE *Project Overview*. Retrieved February 20, 2006, from http://www.hofstra.edu/Academics/SOEAHS/TEC/TEC_NYSCATE_Project_Overview.cfm

New Zealand Qualification Authority. (2002) the Prime Ministers Supreme Award (Welby Ings) in *Tertiary Teaching Excellence Awards 2002.* Retrieved February 13, 2006, from http://www.nzqa.govt.nz/for-providers/awards/docs/ttea-booklet.pdf

Book Review

de Vries, M. J. (2005). ***Teaching about technology: An introduction to the philosophy of technology for non-philosophers.*** **Dordrecht, The Netherlands: Springer. $129.00 (hardcover) pp. 170, ISBN 1-4020-3409-1**

Reviewed by Vincent Childress

Marc de Vries' latest book, *Teaching about Technology: An Introduction to the Philosophy of Technology for Non-Philosophers,* was interesting to the reviewer because it provided a link between philosophies of technology and the nature of the technology curriculum more than any other philosophy-related work he has read. The book is intended for use with pre-service teachers, graduate students, and others who are interested in teaching technology. *Teaching about Technology* is part of a series of books on science and technology that is edited by William Cobern of Western Michigan University in Kalamazoo, Michigan. The editorial board for the series is comprised of university professors from around the world including Ghana, South Africa, Columbia, Hong Kong, and Taiwan. The series, entitled Science and Technology Education Library, is primarily related to science education. The publisher, Springer, is based in Berlin, Germany but has a number of publication outlets around the world and is involved in science and technology related publications generally.

de Vries provides a well organized introduction to the nature of philosophy and helps readers understand fundamental concepts like ontology and epistemology as they relate to the person and knowledge. He provides many examples of how various philosophers have viewed knowledge in the past, and traces a progression of technology philosophers' beliefs up to the present. At this point in the book, he helps prospective teachers of technology understand why having a philosophy is important. He relates the development of a personal philosophy of technology to the curriculum of technology education.

Next, de Vries uses philosophy as a "sieve" through which technologies can be sorted. He starts by characterizing technology artifacts, covering several different philosophical points of view that help the reader organize technology artifacts as content. This is an example of how de Vries uses philosophy to reveal the nature of technology education and its curriculum more than other authors. In a like manner, de Vries describes technological knowledge, technological processes, technological ethics, and aesthetics. Across these

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particular four chapters, artifacts, knowledge, processes, and ethics and aesthetics, de Vries provides a balanced view of technology, what it is, and what people believe about it. Moreover, he makes it a point to discuss the importance of a balanced view of technology and this discussion underscores the importance of, and capitalizes on, Pupils' Attitudes Toward Technology (PATT) research. In light of PATT research in general, it is refreshing that the first four chapters of the book culminate in a balanced view of technology.

In order to make practical use of PATT research in the context of technological philosophies, de Vries moves into everyday perspectives on how to apply the reader's new found knowledge of a philosophy of technology. A chief concern is that the technology teacher should go into the classroom ready to design curriculum and instruction that will address what is currently understood about learners' perceptions of technology. For example, de Vries makes a very important observation about technology and gender:

> An interesting outcome in some of the studies is that the less positive attitude (in terms of interest) with girls is related to a narrower view they have of technology. In the previous section we have seen that pupils…have an artifact-oriented view of technology. This holds for girls even stronger than for boys. And also it appears that this focus on artifacts, rather than on the human and social aspects of technology, makes them less interested in technology. That fits well with many other studies into gender aspects of interests, from which we know that girls more than boys are interested in human and social issues. (p. 108)

de Vries also outlines several perspectives on technology curricula and their origins. He includes portions of the *Standards for Technological Literacy: Content for the Study of Technology* and other prominent curriculum perspectives and relates their structures back to the reader's philosophical perspective. Finally, de Vries outlines several methods of instruction that may be useful in helping students to understand technology.

There are only a few criticisms of the work. The most noticeable problem is the high frequency of mechanical/grammatical errors in writing. The book is written in English, but de Vries is from The Netherlands. The reviewer can only imagine the difficult task of writing in one language and then having to translate those thoughts into another language. However, these errors might only be noticeable in English-speaking countries and will certainly be removed in subsequent printings. Like this reviewer, de Vries has a tendency to be wordy and present content through complex sentences. However, it is difficult to write about such a complicated subject without getting "heavy" on the expression of ideas. A third point, more of an observation than a criticism, is that the methods covered in the book, sequenced near the book's end, are so limited that it seems as if they were afterthoughts or were presented in such a way as to help the author avoid the appearance of dictating what should be done in the technology classroom or laboratory in terms of methods. For example, to the reviewer's recollection, no mention is made of the various ways in which teachers can facilitate students' interactions with technologies. Yet, the reviewer knows that the extent to which a technology program is hands-on, design-oriented, or the like, in part, is a function of the teacher's philosophy. This observation may be based more on the reviewer's biases about particular philosophies than it is based on some shortcoming of the work. It is important from an international perspective that de Vries not try to influence technology teachers to adopt his particular philosophical view on technology. Those decisions are local.

In terms of helping students understand the connections between philosophy and the nature of technology and technology curricula, de Vries' book is a good choice for the classroom. The extent to which a pre-service technology teacher gets excited about philosophies and philosophers (e.g., progressivism and Dewey) is a function of the teacher educator and how he or she intends to design the teacher's introduction to philosophy. Having the de Vries book as a lead-in to the student's development of his or her own philosophy of technology would provide a good foundation from which a series of stimulating discussions could arise.

Miscellany

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