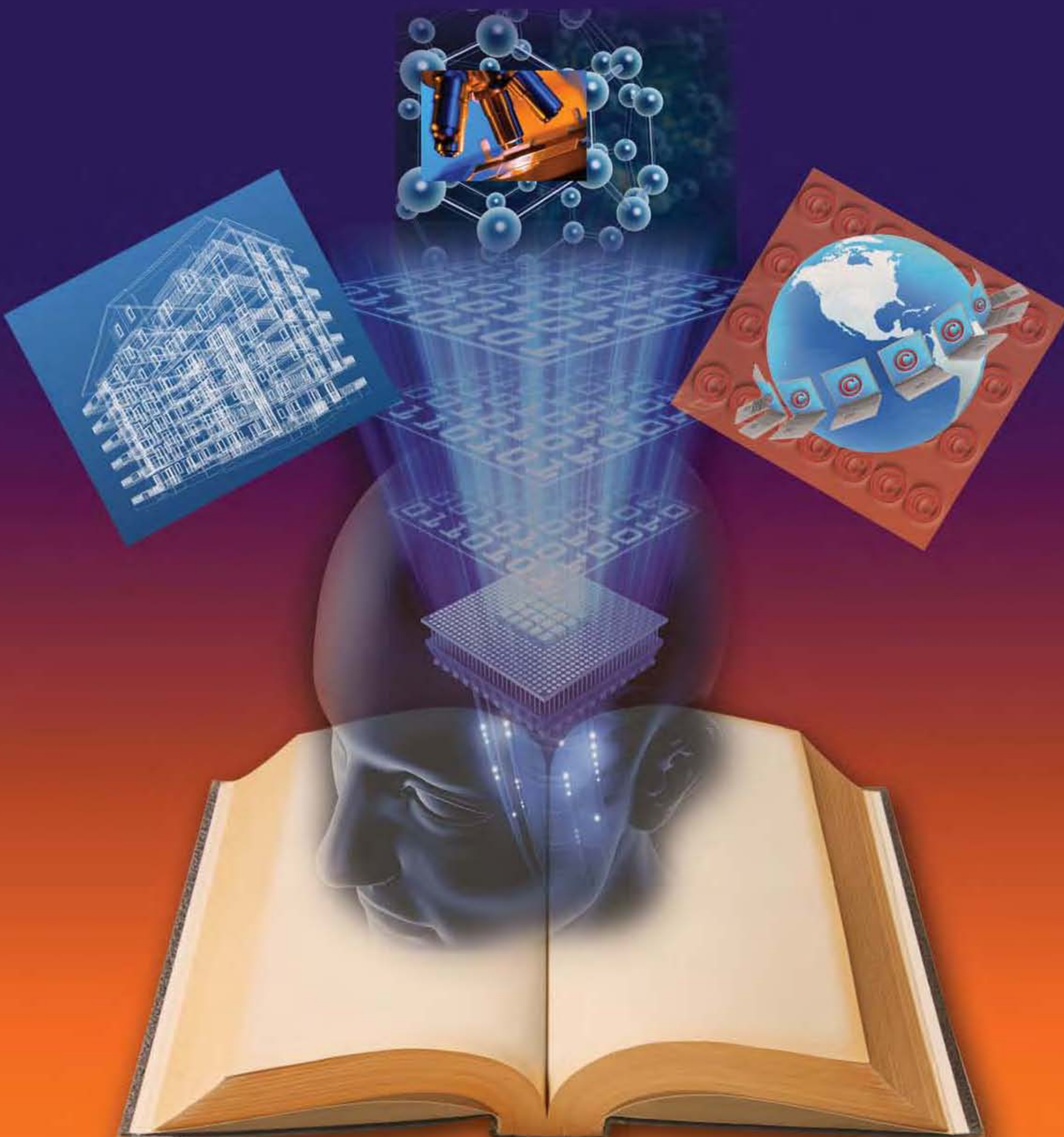
Promoting Excellence in Preparation and Excellence in Practice

Volume XXXIV, 2008
No. 1 Spring 2008



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

The Journal of Technology Studies

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

The Journal of Technology Studies (JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc., a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0296. Use this address or jots@bgsu.edu for subscription matters or purchases.

The opinions expressed by the journal's authors are not necessarily those of the Board of Directors, staff, or members of Epsilon Pi Tau.

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

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

Separate articles or complete issues are also available in a variety of media forms from National Archive Publishing Company, P.O. Box 1346, Ann Arbor, MI 48106-1346, EBSCO Publishing, 10 Estes Street, Ipswich, MA 01938-0682, USA, and ERIC, 655 15th Street NW Suite 500, Washington, DC 20005, USA.

The JTS welcomes original manuscripts from scholars worldwide focused on the depth and breadth of technology as practiced and understood past, present, and future. Epsilon Pi Tau, as perhaps the most comprehensive honor society among the technology professions, seeks to provide up-to-date and insightful information to its increasingly diverse membership as well as the broader public. Authors need not be members of the society in order to submit manuscripts for consideration. Contributions from both academics and practitioners are equally welcome.

A general guide to the breadth of topics of potential interest to our readers can be gained by consideration of the 17 subclasses within "Technology" of the classification scheme of the Library of Congress, USA <lcweb.loc.gov/catdir/cpso/lcco/lcco_t.pdf>. This includes engineering and allied disciplines, informatics in its many manifestations, industrial technology, and education in and about technology.

Authors are strongly urged to consult the journal's "Guidelines for Authors," included in this publication, or available at the society's Web site (www.eptglobal.org) or provided upon request. It provides additional details on the breadth and nature of topics of interest, the journal's scholarly writing standards, submission guidelines, and review and publication processes.

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

Table of Contents

Volume XXXIV, Number 1, Spring 2008

The Impact of Teaching Oxy-Fuel Welding on Gas Metal Arc Welding Skills

Sergio D. Sgro, Dennis W. Field and Steven A. Freeman

Industrial technology programs around the country must be sensitive to the demands of manufacturing and industry as they continue to replace "vocational" curriculum with high-tech alternatives. This article examines whether or not teaching oxyacetylene welding in the industrial technology classroom is required to learn arc welding processes. The results of this study suggests that there appears to be little impact, in terms of gas metal arc welding skills, associated with removing oxyacetylene welding from the curriculum. Because the gas metal arc welding industry is growing globally and industrial technology curricula are under time constraints that often limit the amount of time devoted to welding, faculty should consider suspending oxy-fuel welding to allow more time in gas metal arc welding instruction.

Introduction and Background

Many industrial technology programs struggle to identify and institute curricular activities that adequately serve all of the needs of local and regional industry. In light of "new" technologies, such as CNC, CAD/CAM, and the ever-growing robotics and automation markets, it is no surprise that the perceived importance of vocational skills steadily decreases. But the emphasis during the past decades to pursue less physically demanding careers has resulted in profound labor shortages throughout almost all industries (Brat, 2006), particularly manual welding, as evidenced by a recent *Wall Street Journal* Online Marketplace article:

> The average age of welders, currently 54, keeps climbing. As a wave of retirements loom, welding schools and on-site training programs aren't pumping out replacements fast enough. As a result, many companies are going to great lengths to attract skilled welders, sending recruiters to far-away job fairs and dangling unprecedented perks. (Brat, 2006, p. 10)

Industrial technology programs around the country must be sensitive to the demand for welders as they continue to replace "vocational" curriculum with high-tech alternatives. Entry-level managers who understand the practical as well as the theoretical nature of technology are still required. "The primary distinguishing characteristic of technological knowledge is that it derives from, and finds meaning, in activity" (Herschbach, 1995, para. 28). Much of the facility and vocational equipment infrastructures in industrial technology programs remain intact, albeit a bit dusty, and they should be utilized to revitalize or reorganize hot metals curricula to meet the demands of industry.

This article delves into welding education as its authors consider which processes, if any, are helpful for the student to learn first if he or she is to become proficient in arc welding. In particular, the researchers have chosen oxy-fuel welding (OFW), also known as oxyacetylene welding, and gas metal arc welding (GMAW) as the two test vehicles. Oxy-fuel welding is the oldest welding process that burns oxygen and acetylene in a flame to melt metal beyond its solid state. It has been largely superseded by arc welding (American Welding Society [AWS], 2004). Gas metal arc welding continues to grow globally (Pekkari, 2000) and is used extensively in "industrial manufacturing, agriculture, construction, shipbuilding and mining" (AWS, 2004, p. 148). Gas metal arc welding uses an electric power source, rather than a flame, to produce an arc that melts metal beyond its solid state.

Literature Review

State of the Welding Industry

"The highly increased consumption of solid wires in 1999 over 1998 by almost 35 percent (in USA) reflects extremely good business conditions" (Pekkari, 2000, p. 3). Pekkari (2000) also explained the immense shift from manual metal arc (MMA) (also known as shielded metal arc welding or "stick") to gas metal arc welding in the last quarter of the 20th century. In 1975, manual metal arc utilized just over 50 percent of all arc welding; by the turn of the century, the number had fallen to approximately 15 percent of arc welding. Contrary to its counterpart's demise, gas metal arc welding has ballooned from approximately 20 percent of all arc welding to almost 60 percent (Pekkari, 2000). In fact, Pekkari continues this comparison with the following statement, "The number of arc welding applications has continuously been growing since 1975" (2000, p. 5). More important, many more shops and manufacturing facilities look to robotic welding for reduced production time and increased quality (Harris, 2005).

In 2002, the U.S. Department of Commerce (2002) released a study entitled "Welding-Related Expenditures, Investments, and Productivity in U.S. Manufacturing, Construction, and Mining Industries." The first two major findings of the report represent credible evidence regarding this study that industrial technology students must be adequately prepared to manage current welding technology as effectively as possible within the limited time allotted in the classroom. Those findings are as follows (U.S. Department of Commerce, 2002, p. 1):

1. Welding expenditures represent a substantial contribution to the U.S. economy.
2. By far, labor represents the largest proportion of total welding expenditures.

Recently, *The Wall Street Journal* Online Edition published an article describing how manufacturers, both large and small, are dealing with a shortage in qualified welders (Brat, 2006).

From an educational standpoint, teachers also should be prepared to purchase or update existing equipment that will aid in the preparation of the managers. The need to consider costs is an important component of curriculum considerations.

Cost Considerations for the Metals Lab

Incurred costs fall under four areas: equipment costs, energy costs, labor costs, and material costs (AWS, 2004). Of particular interest to this research are equipment costs and student contact time (actual time welding) on the equipment. The following is a general introduction to the equipment and its use.

Oxy-fuel Welding Equipment

Oxy-fuel welding equipment, also known as oxygen acetylene welding, is relatively inexpensive, portable, and versatile (AWS, 2004). It is used for welding, cutting, brazing, and soldering. A proportionally equal mixture of oxygen and acetylene is burned at a temperature of 5,589º Fahrenheit (Althouse, Turnquist, Bowditch, Bowditch, & Bowditch, 2003). Equipment costs, excluding rented gas cylinders, can range from several hundred dollars (torch outfit and gas regulators) to approximately $1,000.00.

Students must first learn to light the oxy-fuel flame, adjust the neutral flame, and heat up the base metal before beginning to weld. These steps alone, notwithstanding the dangers and nuances of gas regulators and the addition of filler metal, can absorb a lot of class time. This is especially critical for schools that have limited space and limited time in the curriculum allocated to welding. In this situation, a student could spend most of his or her time adjusting the flame, heating up the base metal, or trying to understand the two-handed coordination of creating a puddle, adding filler material, and moving the puddle.

Gas Metal Arc Welding Equipment

Unlike oxy-fuel welding, gas metal arc welding equipment can range from about $2,500 for a stand-alone welder up to $9,000 for a multi-process welding machine. Most gas metal arc welders now come equipped with recommended weld settings for wire speed and voltage. Students are generally able to quickly set dials or similar apparatuses to the intended material thickness and begin welding. No time is needed to adjust the flame, heat up the base metal, or learn how to add filler material into the weld puddle; this is done automatically.

Travel speed comparison

Given that welding is a physical activity, an important function in student learning is allotting as much practice time as possible. One aspect of this learning time can be a function of the welding travel speed. "Travel speed is defined as the linear rate at which the arc is moved along the weld joint" (AWS, 2004, p. 183). Table 1 is an approximate travel speed comparison between oxy-fuel and gas metal arc welding of 0.1875 inch mild steel thick plate. Some of the time difference between welding

Table 1 Travel Speed Comparison – Oxy-fuel Welding Versus Gas Metal Arc Welding

Welding Type	Approximate travel speed (inches per minute)
Oxy-fuel gas welding	2.8 (Althouse, et al, 2003)
Gas metal arc welding	20 - 22 (AWS, 2004)

types is attributed to heating up the base metal and changing or replenishing filler material in oxy-fuel welding, but most important is the welding speed.

Welding Education

Industrial technology students are generally exposed to oxy-fuel welding, shielded metal arc welding, and gas metal arc welding in materials and processes courses. At some institutions, students are asked to perform a practical test to demonstrate a certain level of competency in one or more of these welding processes. It is useful to examine different approaches to welding as it is viewed by several well-known welding schools.

There are many welding schools around the country, but these schools typically teach according to some standard curriculum, usually benchmarking to the American Welding Society's conventions. Given that oxy-fuel welding was the first type of welding and that the process has not changed in over a century (AWS, 2004), it is no wonder that the basic method of teaching welding (from oxy-fuel to arc welding) is still practiced today (Sosnin, 1982). This section gives a brief curriculum overview of the larger, well-known national welding schools with special focus on oxy-fuel and gas metal arc welding. For instance, the Hobart Institute for Welding Technology [HIWT] (2005) has made efforts to upgrade their video/DVD training modules to incorporate current teaching techniques. In particular, the online description of their 24-module GMAW introductory course includes the following overview:

> Each skill module includes a demonstration of the weld that students are expected to perform, featuring dramatic, close-up shots of the arc and puddle. Theory modules contain all the essential information associated with the gas metal arc welding process, and feature attractive animated graphics to illustrate key concepts. Male and female narrators alternate throughout, to maintain student interest and highlight key points (¶ 2).

Modern Welding (Althouse, et al., 2003), a complete entry-level textbook, correlates the entire book and its chapters to the American Welding Society's Guide for Training and Qualification of Welding Personnel – Entry Level Welder learning objectives. These objectives include:

- Occupational Orientation
- Drawing and Weld Symbol Interpretation
- Arc Welding Principles and Practices
- Oxy-fuel Gas Cutting Principles and Practices
- Arc Cutting Principles and Practices
- Welding Inspection and Testing Principles.

It should be noted that oxy-fuel welding is not a principle learning objective but rather a subset of the oxy-fuel gas cutting learning objectives.

Lincoln Electric's Lincoln Welding School (n.d.) covers only the fundamentals of oxy-fuel welding in the introduction to their plasma, oxy-fuel, alloy, and hardening course description.

Need for the Study

Sosnin (1982) summarizes the prevailing anecdotal evidence uncovered by the researchers during conversations and classroom lectures with various vocational instructors regarding welding education: "It has been proven, many times, that when a student learns to weld with an oxyacetylene torch first, he learns to weld quicker and better with the other processes" (p. 48). Unfortunately, no data or research has been uncovered to support that notion. Furthermore, Depue and Pollock (personal communication, October 5, 2005), both American Welding Society (AWS) Educational Division directors, disagreed with the statement unless it was applied exclusively to gas tungsten arc welding, also known as TIG welding. Sosnin (1982) also indicates that oxyacetylene welding (also known as oxy-fuel gas welding) is a traditional method that should be utilized as much as possible in production for economic and efficiency benefits. However, literature that is more current limits the extent of oxy-fuel welding to maintenance and repair exclusively (AWS, 2004).

Today's manual welding industry depends largely on arc welding technology (AWS, 2004), and despite the technological growth of robotic arc welding equipment, there remains a growing need for skilled welders (Althouse, et al., 2003; Brat, 2006). For the industrial technologist, this means, as part of their formal education, more experience is needed for arc welding processes that are currently employed throughout industry in order for them to become better managers of those technologies. As stated previously, many scholars and tradesmen of the vocational era apparently still believe that oxy-fuel welding is the most critical welding process to learn; however, Dolby (2003) found that arc welding has been the primary welding source for half a century. In particular, he stressed its dominance in the engineering construction sector. This is further warranted by the lack of literature pertaining to the use of oxy-fuel welding. For example:

- Air Products, PLC (1999) published its *Welder's Handbook* without any mention of oxy-fuel welding, only oxy-fuel gas cutting.
- Deposition rates and economic sections of welding books and handbooks compare different arc welding processes, but none reviewed compare arc welding to oxy-fuel welding (Depue & Pollock, personal communication, October 5, 2005).
- Early on, it was recognized that welding repair and maintenance work was inherently not steady (Plumley, 1949); a reality the researcher (Sgro) has experienced firsthand as a metal worker over fifty years later.
- In their *Curriculum Guide for the Training of Welding Personnel: Level 1 - Entry Level* (AWS, 2005), oxy-fuel welding is not included as a part of the recommended entry-level welder profile.

To that end, there is a disparity between Sosnin's (1982) assumption regarding the sequence of the welding curriculum versus the direction, and more important, the perceived needs for technical managers of welding in industry. It is the researchers' belief that there are a number of schools that continue to stress the importance of oxy-fuel welding, and its direct benefits to arc welding, without the use of empirical data to support the assumption. To that end, the question becomes: Should faculty devote limited time and resources in industrial technology classes to this technology? This research answers this question both empirically and through literature of current trends in the welding industry.

Purpose of the Study

This study aims to identify whether or not teaching oxy-fuel welding prior to gas metal arc welding, also known as metal inert gas "MIG" welding, under classroom conditions significantly improves gas metal arc welding skills for industrial technology students in a National Association of Industrial Technology (NAIT) accredited, four-year institution. Classroom conditions refer to typical teaching conditions encountered by the students in industrial technology.

Given the advances and enormity of the welding industry (especially in automatic, plastics, and specialty alloy welding), the research was focused on oxy-fuel and gas metal arc welding for the following reasons:

1. "Oxyacetylene is one of the oldest welding processes" (AWS, 2004, p. 468).
2. It was noted that many vocational scholars asserted and still believe learning oxy-fuel welding before arc welding is imperative (Sosnin, 1982).
3. Gas metal arc welding has a higher metal deposition rate than either shielded metal arc welding (SMAW – also known as "stick welding") and gas tungsten arc welding (GTAW – also known as "TIG welding") (Althouse, et al., 2003), a fact that directly affects student practice.
4. No literature has been uncovered that compares oxy-fuel welding directly to gas metal arc welding (Depue & Pollock, personal communication, October 5, 2005).

Many industrial technology programs inherently stress the importance of oxy-fuel welding, and students continue to spend limited class time trying to adequately master the technique.

Research Question

Is there a statistically significant difference in the ability to gas metal arc weld between students who were first taught to oxy-fuel weld (with or without filler) versus those students who were not taught to oxy-fuel weld?

Statistical Hypothesis 1

Ho: μOFW+filler = μOFW-filler = μGMAW

Ha: μOFW+filler $\neq$ μOFW-filler $\neq$ μGMAW

Statistical Hypothesis 2

Ho: μOFW(with and without Filler) = μGMAW

Ha: μOFW(with and without filler) $\neq$ μGMAW

Methodology

Population and Sample

The research was conducted in three sections of an introductory materials processing course (ITEC 130: Production Materials and Processes) in the Department of Industry and Technology at Millersville University in the Spring 2006 semester. The population for this study is industrial technology students with a focus on four-year technical management programs. Each section of the course meets for a total of four hours and 10 minutes of contact time per week. The experiment was conducted during two class periods. During this time, each class was given lecture, manipulative/practice time, and a final gas metal arc welding test. Given that this is all the time that is allotted to welding during other semesters at Millersville University (and sometimes less), it provides an opportunity to perform the experiment under the time constraints of a normal semester. Furthermore, students are given lab time each week, outside the normal course schedule, to practice their skills (not just welding skills) and to complete projects, if they choose to do so.

Prior to the experiment, a survey was administered to each student to collect information pertaining to any prior welding experience. The survey gathered information about which welding process, if any, the student had previously learned. When a student indicated prior welding experience, he or she was asked to specify between (a) oxyacetylene welding (not oxyacetylene cutting), (b) shielded metal arc welding, (c) gas metal arc welding, (d) gas tungsten arc welding, or (e) some other type not identified above. In addition, those students who indicated prior welding experience were asked to complete how much welding time was spent on the specified welding experience. Three choices were available for each welding process selection, they were: (a) greater than zero but less then two hours of experience, (b) two to twenty hours of welding experience, or (c) greater than 20 hours of experience.

Statistical Design

The study is a one-factor experiment with three treatment groups with two stages of analysis. Stage one is a one-way analysis of variance (ANOVA) with three treatment groups and one factor of interest. The treatment groups and sample sizes can be found in Table 2.

On day one of the study, each group was taught and practiced only one type of welding [oxy-fuel with filler (OFW+F), oxy-fuel without filler (OFW-F), or gas metal arc welding (GMAW)]. On day two, each class practiced and was immediately tested on gas metal arc welding. Each weld was independently evaluated by two welding instructors for seven pre-defined characteristics on a 1 to 10 scale. The two evaluators' scores were averaged for each of the seven scores, and those seven averaged scores were used to compute an overall mean score per student. In order to evaluate the effect of oxy-fuel welding (with and without filler, collectively) on gas metal arc welding skills, the effects of oxy-fuel welding were pooled together and compared to the gas metal arc welding group.

Stage two of the experiment is an evaluation of how students performed on specific parts of the weld. More specifically, it evaluated whether teaching oxy-fuel welding prior to gas metal arc welding significantly improved any gas metal arc welding test characteristics. An analysis of variance with a narrow alpha level (0.01) was used for each individual test. A narrower alpha level for each of the seven tests, called a Bonferroni correction, was used to ensure a higher confidence level overall (Agresti & Finlay, 1997).

The researcher (Sgro) utilized lectures previously given to ITEC 130 students in the Spring 2004 semester when he was an instructor at Millersville University. The lecture material follows the curriculum guide of the American Welding Society (for GMAW only).

Practice

The experiment spanned two class periods. Day one was largely devoted to introduction of welding and practicing the weld process assigned to that particular class. Day two included instruction with a shorter practice time and the actual welding experiment on the gas metal arc welding

Table 2 Experimental Setup of Three Groups

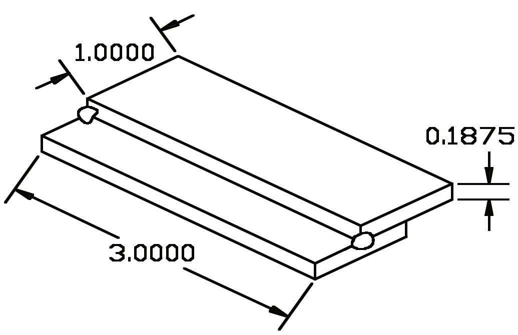
Group/Class	Treatment Groups	Total
1	OFW w/ Filler + GMAW	24 Students
2	OFW w/out Filler + GMAW	20 Student
3	GMAW + GMAW	24 Students

process. The following procedures describe what was taught and demonstrated in each class, respectively. Given that there were only two oxygen acetylene torch outfits and one gas metal arc welder, practice time was limited to two minutes per student. During the oxy-fuel practice times, lighting and flame adjustment was demonstrated and then the torch was handed to the student. Each student practiced for a total of two minutes. For the class that was taught how to add filler material into the weld puddle, practice time was divided into two parts. One minute was allowed for puddle creation and moving, and one minute was allowed for practicing puddle creation, adding filler material, and then moving the puddle. Those students who did not have any oxy-fuel training practiced for two minutes on gas metal arc welding.

Testing

On the second day of the experiment, each group was given the same practice/testing sequence on gas metal arc welding. Every student practiced for one minute on an unmarked lap joint. Immediately following the one minute of practice, the students welded the test specimen lap joint to the best of their ability. There was no guidance during the final welding test. An example of the lap joint test specimen is shown in Figure 1. Each student was randomly called to perform the test.

Figure 1. Lap Joint Test Specimen designed by Sergio Sgro for experiment.



An Airco Dip-Pak 250 welder was used for practice and testing of all participants. The welder was set to the manufacturer's recommended short-circuiting arc voltage and wire feed for 0.1875 inch thick mild steel with 0.035 inch diameter wire using 75% Argon – 25% Carbon Dioxide shielding gas. The welder was set to "1" on the medium voltage range and "4" for the wire feed speed. Although the Dip-Pak 250 is no longer manufactured and no manuals for the welder could be found, the actual voltage (20 Volts) and wire feed speed (265 inches per minute) can be estimated using the Typical Conditions for the Gas Metal Arc Welding of Carbon and Low-Alloy Steels in the Flat Position (Short-Circuiting Transfer) of the American Welding Society Welding Handbook (AWS, 2004, p. 186).

Inspection

Two welding instructors from the Lancaster County Career and Technology Center, Lancaster, Pennsylvania, inspected each test specimen on each of the following seven quality characteristics: (1) Test 1-- weld height, (2) Test 2 - weld width, (3) Test 3 - undercut, (4) Test 4 - uniformity of weld, (5) Test 5 - proper contour, (6) Test 6 - surface contaminants/porosity, and (7) Test 7 - penetration at top. This rubric was developed jointly by the researchers and the welding instructors to identify areas the instructors consider for their beginning students. At this level of competency and practice time, that is, with only a few minutes of practice time, it was not deemed appropriate to perform mechanical testing. Visual inspections determine whether or not the students understand the basic concept of creating and moving a molten weld puddle.

Results

The data table for all seven tests are presented next.

The one-way analysis of variance of the overall mean scores between oxy-fuel welding with filler, oxy-fuel welding without filler, and gas metal arc welding indicated no significant differences at the 0.05 alpha level ($p = 0.168$).

Table 3 Data Table and Overall Mean Scores

Group	n	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Overall Mean	SD
OFW+F	24	3.52	2.53	7.40	3.42	2.85	7.19	5.23	4.59	1.95
OFW-F	20	2.83	2.90	7.18	3.23	1.63	6.50	6.25	4.36	1.54
GMAW	24	4.92	3.73	6.54	4.46	3.25	7.90	6.56	5.33	1.83
Overall	68	3.81	3.06	7.03	3.73	2.63	7.24	6.00	4.79	

Table 4 Analysis of Variance for the Three Individual Groups

Source	df	F
Instructional Method	2	1.835
Error	65	

Note. $*p < .05$.

A subsequent analysis comparing oxy-fuel welding, with and without filler, versus gas metal arc welding was performed using the least squares contrast function of JMP 6.0 (SAS Institute, 2005) with coefficients of -0.5, -0.5, and 1 for oxy-fuel welding with filler, oxy-fuel welding without filler, and gas metal arc welding, respectively. The contrast compares the averages of the oxy-fuel welding groups, collectively, to the third group, gas metal arc welding, utilizing the pooled estimate of variance for all three groups. Based on the contrast test, there is no significant difference in overall welding scores between those students who first learned to oxy-fuel weld versus those students who did not learn to oxy-fuel weld.

Table 5 Analysis of Variance for Oxy-fuel, with and without Filler, Versus Gas Metal Arc Welding

Source	df	F
Instructional Method	1	3.562
Error	65	

Note. $*p < .05$.

Given that the overall mean scores are made up of the seven individual test scores, a one-way analysis of variance was performed to assess whether any of the seven welding characteristics tested were significantly different between the oxy-fuel and gas metal arc welding groups. In this analysis, oxy-fuel welding with filler and oxy-fuel welding without filler were once again contrast ($n = 44$) and compared to the gas metal arc welding group ($n = 24$). Each of the seven tests was performed on the weld specimens thereby making each test dependant on the other six tests. An adjustment was made for simultaneous confidence intervals with alpha = 0.01 for each individual test (this is an approximation for the Bonferroni correction: 0.05/7 = 0.00714) for an approximate total margin of error equal to 0.05. The analysis of variance results for each weld test are presented below.

Of the seven weld characteristics evaluated, Test 1 (weld height) was the only characteristic statistically significant at the 0.01 alpha level ($p = 0.007$). For Test 1, those students who were taught gas metal arc welding scored higher than those students who were taught how to oxy-fuel weld first. Test 2 through Test 7 were all found to be not significant at the 0.01 level: there was no significant difference between those students who were taught oxy-fuel welding versus those who were not taught oxy-fuel welding. The error term in the analysis of variance table above is 65 degrees of freedom per test. A graph of the mean scores for each of the seven tests is shown in Figure 2.

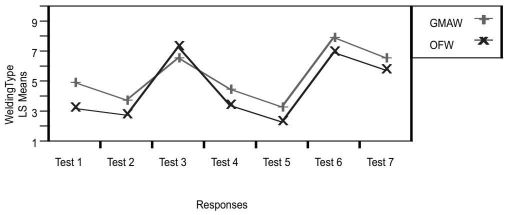
The graph illustrates that on average, students tend to weld better in certain areas than they do in others, regardless of their initial welding instruction.

Table 6 Analysis of Variance for each Individual Test

Source	df	F
Test 1	1	7.734**
Test 2	1	2.621
Test 3	1	2.960
Test 4	1	4.490
Test 5	1	4.635
Test 6	1	2.917
Test 7	1	1.470
Error	65 *error term applies to each test*	

Note. $**p < .01$

Figure 2. Line Graph of the Seven Tests.



Discussion

The results of this research revealed that there is no statistically significant overall difference in arc welding skills between those students who were first taught to oxy-fuel weld versus those who were not taught to oxy-fuel weld. In fact, of the seven individual characteristic tests on each weld specimen, one individual weld test suggested that students who did not oxy-fuel weld performed better than those who were taught to oxy-fuel weld ($p = 0.007$). Under the conditions of this research, the outcomes did not support Sosnin's (1982) assertion that students learned to weld other processes better and faster if they were first taught to oxy-fuel weld. To that end, recommendations are presented in support of an industrial technology welding curriculum without the use of oxy-fuel welding. It should be noted that these recommendations are for industrial technology programs whose main focus is technology management, when time constraints must be considered, not welding. The outcome of the research does not affect or impede the importance of learning oxy-fuel welding when gas tungsten arc welding or oxy-fuel welding and cutting will be a significant skill set the student will learn for his or her profession.

From the surveys given before the experiment, over half of the students had no previous welding experience. Some students indicated some experience in either oxy-fuel welding, shielded metal arc welding, gas metal arc welding, and/or gas tungsten arc welding. Although it makes sense to account for experience statistically (those with more experience scored significantly higher), it is typically not practical to separate those in an industrial technology class into those with and without experience. Additionally, sample sizes for the experience covariate, especially specific experience in any of the aforementioned categories, were reason for concern and were therefore not included in this analysis.

The literature pointed to a global increase in gas metal arc welding solid wire consumption (Pekkari, 2000). This is further supported by the U.S. Department of Commerce's (2002) findings that welding expenditures make up a substantial contribution to our economy, especially the labor portion, as well as a recent Wall Street Journal Online Edition (Brat, 2006) citing the present welding labor shortages. These economic indicators, coupled with the time a student can spend learning arc welding skills, call for efficient and effective instructional methodologies when time is limited.

One can argue that oxy-fuel welding equipment is significantly less expensive, but the cost of the equipment versus the time students spend creating and moving puddles is generally ignored. Based on the material thickness and travel speed time figures presented in the literature review, a student using gas metal arc welding can weld over seven times the amount of linear distance than a student using oxy-fuel welding. These numbers are conservative given that they do not include learning curves for understanding how to properly light and adjust a torch, as well as the coordination required to add filler material with a second hand. Generally speaking, welding schools no longer teach oxy-fuel welding as a major welding component, but rather they incorporate it into a cutting and brazing program.

Future research in welding education is recommended to better understand where the true differences in learning each type of welding exist. This study indicated that those who were taught only gas metal arc welding performed better on welding height, but why? Subsequent studies should focus on longer practice time for both types of welding, whereby true welding skills are developed and then tested using both destructive test methods, such as tensile tests or bend tests, as well as nondestructive and visual tests. Experiments should be set up to effectively evaluate different aspects of the weld (height, undercut, porosity, etc.) as well as strength and penetration. One suggestion to validate the findings of this research would be to increase the sample size of the groups and perform multiple tests on students as more practice is given to improve their skills. In doing so, researchers can better understand where beginning welders are typically stronger or where better teaching methods are required. Understanding where students struggle can be a powerful mechanism for streamlining the initial learning of welding. The field of Industrial technology could benefit immensely in terms of time and program effectiveness by teaching welding more efficiently.

Technology programs, in particular those with welding, must keep students and industry in mind – this means that gas metal arc welding is a critical component of the industrial technology curriculum.

Dr. Sergio Sgro is an Assistant Professor in the Department of Technology at Eastern Kentucky University, Richmond, and is a member of the Alpha Xi Chapter of Epsilon Pi Tau.

Dr. Dennis Field is a Professor and Coordinator of the Industrial Technology program in the Department of Technology at Eastern Kentucky University, Richmond, and is a member of the Alpha Xi Chapter of Epsilon Pi Tau.

Dr. Steven A. Freeman is a Professor in the Department of Agricultural and Biosystems Engineering and Assistant Director of the Center for Excellence in Learning and Teaching at Iowa State University, Ames. He is a member of the Alpha Xi Chapter of Epsilon Pi Tau.

References

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

Air Products PLC (1999). *Welder's handbook for gas shielding arc welding, oxy fuel cutting & plasma cutting (3rd ed.).* Air Products PLC.

Althouse, A. D., Turnquist, C. H., Bowditch, W. A., Bowditch, K. E., & Bowditch, M. A. (2003). *Modern welding.* Tinley Park, IL: Goodheart-Wilcox.

American Welding Society [AWS]. (2004). In A. O'Brien (Ed.). *Welding handbook (9th ed.): Vol. 2, Welding Processes, Part 1.* Miami, FL: American Welding Society.

American Welding Society (2005). *Curriculum guide for the training of welding personnel: Level I - entry level (Draft).* Unpublished manuscript.

Brat, I. (2006). *Where have all the welders gone, As manufacturing and repair boom? Wall Street Journal Online.* Retrieved August 18, 2006, from http://webreprints.djreprints.com /1531490511822.html.

Dolby, R. E. (2003). Trends in welding processes in engineering construction for infrastructure projects. *Paper presented at the 56th IIW Annual Assembly, 6 - 11 July 2003, Bucharest, Romania.*

Harris, R. (2005). Creating competitive businesses. [Electronic version] *Welding Design and Fabrication, 78,* 4.

Herschbach, D. R. (1995) Technology as knowledge: Implications for instruction [Electronic version from digital libraries and archives]. *Journal of Technology Education, 5,* Retrieved August 20, 2006, from http://scholar.lib.vt.edu/ejournals/JTE/v7n1/herschbach.jte-v7n1.html.

Hobart Institute of Welding Technology [HIWT]. (2005). HIWT Gas metal arc welding basic (GMAWB). Retrieved November 8, 2005, from http://www.welding.org/cart/training/gmawb.htm.

Lincoln Electric (n.d.) The Lincoln Welding School. Plasma, *Oxy-Fuel, Alloy, & Hardfacing.* Retrieved September 4, 2006, from http://content.lincolnelectric.com//pdfs/knowledge/training/weldschool/LWSAlloy.pdf.

Pekkari, B. (2000, November). *Trends in joining, cutting, and a sustainable world.* Paper presented at The Richard Weck Lecture at the Institute of Materials, London, UK.

Plumley, S. (1949). *Oxyacetylene welding and cutting (4th ed.)*. New York: McGraw-Hill.

SAS Institute Inc. (2005). JMP (Version 6.0.0) [Computer software]. Cary, NC: SAS Institute.

Snedecor, G. W. & Cochran, W. G. (1989). *Statistical methods (8th ed.)*. Ames, IA: Iowa State University Press.

Sosnin, H. A. (1982). *Efficiency and economy of the oxyacetylene process. The Welding Journal, 61,* 46-48.

U.S. Department of Commerce, Bureau of Export Administration, Office of Strategic Industries & Economic Security (2002). *Welding-related expenditures, investments, and productivity in U.S. manufacturing, construction, and mining industries.* (OMB Control No. 0694-0019, Ref. No. 1WAAELIM). Washington, DC: U.S. Department of Commerce. (Available Online at http://www.aws.org/research/HIM.pdf).

Design and Implementation of an Interdepartmental Biotechnology Program Across Engineering Technology Curricula

Kari Clase

Abstract

The health industry is an important and growing economic engine. Advances are being made in pharmaceutical and biotechnology discoveries and their applications (including manufacturing), as well as in health care services. As a result, there is an increasing sophistication of the products and services available and being developed, with an ever-widening scale of applications and marketing, producing an ever-expanding need for college graduates who have knowledge of life science-based products and processes. There have been numerous reports of current and projected shortages of human resources possessing the required knowledge in the growing industry. The objectives of this paper are to describe the implementation of a biotechnology program that crosses discipline boundaries, integrates science and technology, and attracts a diverse group of students. The curriculum addresses critical workforce needs and teaches students the content knowledge and skills of emerging biotechnology industries.

Introduction

The health industry is an important and growing economic engine. Advances are being made in pharmaceutical and biotechnology discoveries and their applications (including manufacturing), as well as in health care services. As a result, there is an increasing sophistication of the products and services that are both available and being developed, with an ever-widening scale of applications and marketing, producing an ever-expanding need for college graduates who have knowledge of life science-based products and processes.

The field of biotechnology relies on harnessing the properties of a living organism to develop and manufacture products that benefit human life. Innovative research has the power to create new industries that drive the nation's economy (National Research Council [NRC], 2007; U.S. Department of Energy [DOE], 2005) and the synergy of biological sciences with numerous technologies is predicted to provide solutions to major national problems in the 21st century by creating new generations of industrial biotechnology with great potential for economic impact (Commission on Life Sciences, 2000; Herrara, 2004; Littlehales, 2004; USDOE, 2005). Scientific advances, such as elucidating the structure and molecular mechanisms of DNA, have caused exponential growth in the biotechnology industry over the past decade. The acquisition of vast amounts of information generated by the decoding of the sequence of the human genome, as well as multiple other eukaryotes, prokaryotes and viruses have been generated by "-omics" -type experiments such as genomics, proteomics and inonomics. The advances in science and technology are affecting the health industry, including pharmaceutical applications, and workforce needs in biotechnology manufacturing are anticipated to grow as illustrated by the following quote:

> The biotechnology industry is still in its adolescence, but it is about to have a major impact on health care. A third of drugs in phase III clinical trials are proteins. . . . biotech companies are gearing up to manufacture product but they face a shortage of talent, as most young scientists interested in biotechnology have congregated to research. (Kling, 2004, p. 1)

The field of biotechnology extends beyond the health industry and into applications of energy. Due to continuous economic and industry growth, world energy consumption is expected to increase 71 percent from 2003 to 2030 (AEO, 2006). The energy solutions of the future will require a significant amount of research and development in energy technologies. Alternative energy solutions in the form of biofuels could help meet the emerging energy needs (Abraham, 2004; Pacala & Socolow, 2004; Socolow, 2005). Biofuels could be produced using plants, microbes, or even engineered nanobiostructures; in fact, biotechnology-based energy use could equal current global fossil energy use by 2100 (DOE, 2005). Thus, there is a need to promote an educated and skilled workforce capable of understanding and working with emerging areas of biotechnology, such as alternative energy technologies, both in the development of new energy sources and the use and maintenance of emerging developments. As reported in the meeting summary for the Pan-Organizational Summit on the U.S. Science and Engineering Workforce, technical skills combined with a strong math and science background and integrated with problem-solving, critical-thinking, and teamwork skills are sorely needed by modern manufacturing as well as by other sectors (Fox, 2003; NRC, 2007; Pearson, 2002). Industrial applications of biotechnology and effective solutions to global health and energy problems will cross discipline boundaries and require an adequately prepared workforce (NRC, 2007). Students need programs and curriculum that will educate them beyond their single discipline in order to help them meaningfully embrace interdisciplinary conceptual systems and ways of thinking and help prepare them for the future. In order to address the gap between education and workforce, Purdue University approved an academic minor in Biotechnology, an interdisciplinary effort among the Colleges of Pharmacy, Science, and Technology. Through this partnership, multidisciplinary laboratory activities were implemented, which use appropriate instrumentation and cover technologies currently employed in biotechnological research.

Educational Objective of the Biotechnology Program

The educational objective of the biotechnology program is to create an interactive laboratory learning environment and immerse undergraduate students within action-based research. The curriculum was developed to address identified goals for laboratory experiences (Singer, Hilton, & Scweingruber, 2005):

- Enhancing mastery of subject matter
- Developing scientific reasoning
- Understanding the complexity and ambiguity of empirical work
- Developing practical skills
- Understanding of the nature of science
- Cultivating interest in science and interest in learning science
- Developing teamwork abilities.

A large body of recent research from educators and cognitive scientists has shown that by actively engaging undergraduate students in research, their retention of scientific principles and learning retention increases (Bransford, et al, 1999; Campbell, 2004). Recent articles have emphasized the need to revitalize educational practices (Bell, 2009; Mervis, 2008). Within the biotechnology program, students learn to pose authentic research questions and actively participate in the inquiry and discovery process. The students are directly involved in the experimental design, data analysis, and dissemination of the results. Higher order learning with action-based research and curriculum should increase analytical skills and better prepare students for real-world jobs by enabling them to transfer curriculum-based research experiences into the biotechnology industry.

Connection between Purdue University's College of Technology Strategic Plan and the Biotechnology Program

The biotechnology program helps support the strategic plan for Purdue University by improving the learning environment for students and encouraging interdisciplinary research connections among students and faculty. In addition, the program helps harness Purdue's strengths in life sciences and technology and provides graduates to help future growth and development in biotechnology. As stated in the strategic plan (College Of Technology, 2003), the College of Technology educates professional practitioners and managers of science and engineering-based technologies and community leaders, accelerates technology transfer to business and industry, and develops innovations in the application of emerging technology through learning, engagement, and discovery.

To fulfill its mission, the College of Technology strives to provide a student-centered learning environment in which "technology-intensive instructional laboratories are maintained at state-of-the-practice currency as the keystone of practitioner-focused learning (COT, 2003, p.5)." The College of Technology's strategic plan also puts importance on "support for programs that foster the development of innovative instructional strategies, curriculum and laboratory development." (COT, 2003, p.4) The biotechnology program is an example of a forward-thinking effort that helps fulfill the mission of the College of Technology; the courses enhance learning, discovery, and engagement in the following areas:

Technology and Life Sciences

Allow students to engage in hands-on genomic, proteomic, and bioinformatics life science applications within the biotechnology laboratory

Security and Forensics

Students interested in forensics benefit from biological understanding of the processes analyzed in a forensics laboratory, and they learn the life sciences applications within the biotechnology laboratory

Advanced Manufacturing

Industries need students who have life science skills coupled with manufacturing knowledge to prepare them for manufacturing biologically active (life science-based) products. Students that complete the biotechnology program have the unique skills required for life science industries

Workforce Development

Prepare graduates to achieve the integration and effective use of life science technology in the area of biotechnology through laboratory-based instruction, thus improving student learning and discovery

Impact of New Course (Biotechnology Lab I)

The biotechnology program integrates science and technology disciplines and includes the courses described in Table 1. The multidisciplinary program has been attractive to students across campus and students from several colleges have participated in the biotechnology program, as illustrated in Table 2. The background and experience level of the students varied widely and it has been challenging to design appropriate curriculum for this diverse group of learners. Interestingly, graduate students who are crossing discipline boundaries, also enrolled to learn biotechnology concepts and techniques.

Courses within the Biotechnology Program

As illustrated in Figure 1, Biotechnology Lab I serves as one of the primary entry points into the biotechnology program and also has a direct impact upon Biotechnology Lab II and Introduction to Bioinformatics. Biotechnology Lab I is a 2-hour course intended for undergraduate students, and it serves as a prerequisite for Biotechnology Lab II and Introduction to Bioinformatics, courses that compose new core curriculum in the biotechnology program. Biotechnology Lab I has no prerequisites and thus serves as one of the primary entry points into the biotechnology program.

Table 2. Students Participating in the Minor and Their College

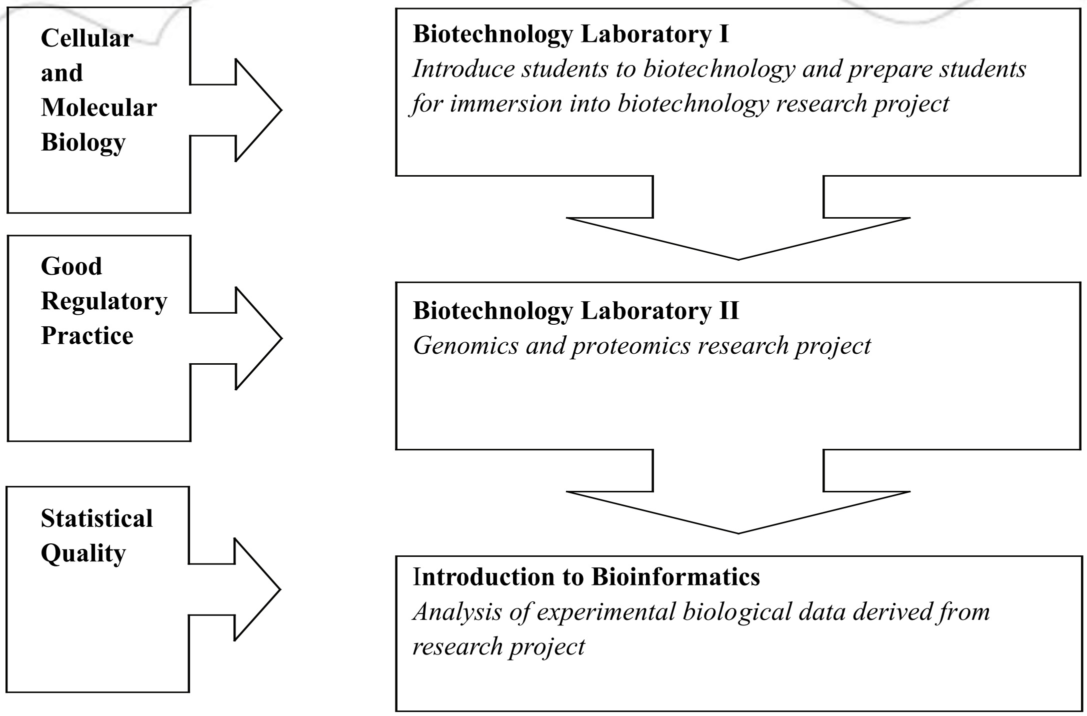
College	Number of students
Agriculture	3
Engineering	4
Liberal Arts	5
Management	5
Pharmacy	10
Science	33
Technology	29
Graduate	4

Collaborations with other programs, departments, and centers on campus have been instrumental to the growth of the program and have helped create a unique learning environment for the students. Most significantly, a recent partnership with Bindley Bioscience Center at Discovery Park has provided access to unique instrumentation for the biotechnology laboratory courses. Purdue University's Discovery Park is an administrative unit outside the traditional academic departments that is a model for the conduct of interdisciplinary discovery, learning, and engagement with society. The Bindley Bioscience Center [BBC] at this Discovery Park blends life sciences and engineering research to cultivate and support

Table 1. Biotechnology Courses within the Minor

Course Number	Course Name	Department
BIOL 112	Fundamentals of Biology I	Biology
BIOL 113	Fundamentals of Biology II	Biology
BIOL 241	Biology IV: Genetics and Molecular Biology	Biology
BIOL 295E	The Biology of the Living Cell	Biology
IT 226	Biotechnology Lab I	Industrial Technology
IT 227	Biotechnology Lab II	Industrial Technology
CPT 227	Introduction to Bioinformatics	Computer and Information Technology
IPPH 522	Good Regulatory Practice	Industrial and Physical Pharmacy
IT 342	Introduction to Statistical Quality	Industrial Technology

Figure 1. Interrelationships of biotechnology courses within the minor.



innovative, multi-investigator, interdisciplinary research teams. BBC engages biosciences in a broader perspective with applications of new or emerging technologies. The Center has established new research infrastructure to apply analytical methods, precision measurement technologies and high throughput approaches to biological systems. BBC research activities are organized around four research core facilities in which multiple high-end technologies are applied to biological systems in the context of senior BBC research scientists with deep expertise in these technologies. A major push is to assemble the requisite expertise to apply and develop technologies for a fuller approach to the complexity of biological systems.

Course Activities: Bioinformatics Modules

Introductory bioinformatics modules were completed before beginning laboratory work at the bench. Bioinformatics case studies were developed to help address the students' preconceived ideas of what scientific research is and what the field of biotechnology involves. The bioinformatics modules helped illustrate the following:

- Biotechnology research does not start at a lab bench; research begins by exploring the background, discovering what other scientists have already published, and determining what research questions remain unanswered.
- Inquiry and discovery within the field of biotechnology involves analysis of complex biological systems with many interacting molecules.

The specific objectives for the Biotechnology Lab I course are shown in Table 3.

Course Activities: Biotechnology Explorer Modules

The biotechnology lab modules that were incorporated into the course were obtained from the biological supply company, Bio-Rad. Bio-Rad has designed laboratory modules appropriate for an introductory biotechnology laboratory course as part of the Educational Explorer program (BIO-RAD, n.d.). The labs were selected for several reasons:

- They help address goals stated earlier for laboratory education especially understanding the complexity and ambiguity of empirical work, developing practical skills, and developing teamwork abilities (Singer, et al, 2005).
- They are affordable.
- They provide laboratory experience in a wide variety of biotechnology techniques with research quality instrumentation.
- They provide appropriate background material to explain the techniques employed and their impact on the current field of biotechnology.

- They have pre-lab and post-lab focus questions that help teach students critical thinking skills as part of the inquiry and discovery process.
- There is minimal lab preparation time investment.
- They have been validated by several other biotechnology programs.

During the first implementation of Biotechnology Lab I, the following biotechnology experiences were provided:

- Deoxyribonucleic acid (DNA) and protein fingerprint analysis.
- Polymerase chain reaction (PCR) informatics analysis.
- DNA and protein separation by electrophoresis.
- Enzyme-linked immunoabsorbant assay (ELISA) immunoassay.
- Bacterial transformation and recombinant gene expression.
- Protein chromatography.
- Nucleic acid isolation.

A laboratory notebook was maintained to record experimental data and organize information provided for laboratory activities. In addition, upon completion of each module, a laboratory report was prepared following the general format depicted in Table 4.

Course Activities: Critique of a Scientific Journal Article

As discussed earlier, it is important for students to develop scientific reasoning, understand the complexity and ambiguity of empirical work, understand the nature of science and cultivate an interest in science (Singer, et al., 2005). One of the activities developed to address these goals was the critique of a scientific journal article. Students were instructed to select an article on a current biotechnology topic that interested them from a secondary source. Then, they were instructed to find the original sources cited in the secondary source, and subsequently critique the primary source(s), comparing and contrasting to the secondary source. Students were encouraged to cultivate an interest in science by selecting a current topic that interested them. The student selections and subsequent critiques suggested they were addressing workforce needs identified earlier by integrating science and

Table 3. Biotechnology I Courses Objectives

General Objectives	Activities	Learner Outcomes and Assessment
The student will gain literacy in the basic methods and applications of bioinformatics	A. Bioinformatics Modules	Bioinformatics Lab Report
The student will be able to perform techniques currently molecular, and microbiology, while understanding the rationale behind the specific approaches	B. BioRad Biotechnology Explorer Modules	Participation in hands-on laboratoryactivities used in cell, and Lab Notebook
The student will be able to explain the experimental basis of techniques used, indicating the significance of the work, presenting, calculating, and discussing the data, and drawing conclusions	B. BioRad Biotechnology Explorer Modules	Lab Report
Given a specific biological question, the student will be able to determine appropriate applications of specific cell, molecular, and microbiological techniques	B. BioRad Biotechnology Explorer Modules	Lab Report
The student will gain experience in dissecting and extracting pertinent information from scientific journal articles	C. Class Discussion & Critique of Scientific Journal Article	Research Report on Scientific Journal Article

Table 4. Format for Lab Report

Section	Pertinent Information
Introduction	Provide background information including previous work by others (cite references), state the hypothesis for this current report, the significance of the project, and in general, the approach used
Methods	State each method used, the purpose of each method and, in sentence form, the method. Then add the page numbers from your lab notebook that reference the appropriate protocol.
Results	State each result and provide data in figures and tables
Discussion	Restate results, now interpreting the findings. Compare these findings to previous publications (cite references). State the significance of the current work and possible future directions.
References	Cite at least 5 references using APA format

technology. For example, although students often selected popular news sources as secondary sources, some students explored the assignment from a different perspective and selected unique secondary sources. For example, many chose to focus on papers that discussed new technology development that affected human health. Other students selected websites that disseminated science and technology information including genomics data from the Sorcerer II Global Ocean Sampling Expedition project (http://camera.calit2.net) and biotechnology intellectual property and patent information from an independent non-profit consultancy fostering innovation and creativity through the better use of intellectual property and its alternatives (The Innovation Partnership (http://www.theinnovationpartnership.org/en/).

Course Evaluation

A Small Group Instructional Diagnosis (SGID) was conducted by the Center for Instructional Excellence at Purdue University to determine what components of the curriculum were effective and what components were ineffective. This method of formative assessment has been shown to improve student motivation and was developed by researchers at the University of Washington to "to generate student feedback to instructors about the courses' strengths, areas needing improvement, and suggestions for bringing about these improvements (Clark & Redmond, 1982). The SGID procedure is conducted in the following manner: "At the beginning of the class, the teacher introduces the guest evaluator and then leaves the room for 20 minutes. During that time, the evaluator asks students to cluster into groups of five or six and take 10 minutes to (a) select a spokesperson who will write down the group's comments, (b) name something in the course they find very helpful or worthwhile, (c) name something they would like to see changed, and (d) suggest how the course could be improved. After the groups have completed their work, the evaluator asks the spokesperson from each group to give a report. The evaluator summarizes the points of consensus for the entire class and also clarifies points of disagreement. The evaluator then provides an oral or written summary for the instructor (Fox & Hackman, 2003, p. 81)." The results from the SGIDs conducted in the biotechnology courses are summarized in Table 5.

The feedback from the SGID is encouraging, but it has also helped inform appropriate course adaptations. Many different textbooks have been tried, however, an appropriate textbook has not been found that truly integrates the life sciences with technology. Currently, the instructor is developing a laboratory packet that will provide the appropriate background theory for the interdisciplinary research projects. Student feedback also indicates that students prefer the use of technologies to enhance the classroom activities. Current work includes developing virtual reality modules for instruction and integrating the laboratory packet with online tutorials, animations and quizzes.

The Biotechnology courses have no prerequisites, and based upon the feedback from the SGID more theory must be provided prior to the hands-on activities in order to ensure that students from all disciplines feel prepared and knowledgeable. As noted previously, the student population within the biotechnology courses is diverse and it has been difficult to design a curriculum that is appropriate. Data is currently being collected on student content knowledge before and after the biotechnology courses to more adequately address the specific educational needs of the students. Both concept inventory tests and open-ended content knowledge

Table 5. Small Group Instructional Diagnosis (Biotechnology Lab)

I. What do you like about this course?	
Course Organization and Structure	The class size is small; The lab experiments are well designed; the course is cohesive with other courses (e.g., reinforces topics that were discussed in genetics classes)
Course Content	Course covers a wide range of topics and allows the students to experience many areas of study; Course uses current lab technologies and techniques and current projects; course provides students with different aspects of the content (theory —> application —> industrial application); there is updated technology used in the lab;
Instructor Characteristics	Instructor is easy to contact via email and responds quickly; instructor explains well; The instructor is knowledgeable, available, and cares about the students
Teaching Techniques	Course requires students to utilize different sources to find information; students learn to use the sources that are used by professionals in the field; students are encouraged to think outside the box and to use their creativity;
II. What specific suggestions do you have for changing this course?	
Course Organization and Structure	Use Web technology more often and don't require the book for class; provide students with a more detailed syllabus; have all protocols in one manual; better prepare students for the lab especially at the beginning of the semester; assure that students with no or little biology background are brought up to speed for the background knowledge in biology that is needed for the course;
Evaluation and Grading	Give ungraded/bonus quizzes that allow students to see how well they understand the material

questions designed to identify misconceptions are being used. Scoring of content knowledge questions will be adapted from the rubric developed by Emert and Parish and student answers will be scored using a Likert scale in the following manner:

- 3--conceptual understanding apparent; complete or near-complete solution/response.
- 2--conceptual understanding only adequate; incomplete solution/response.
- 1--conceptual understanding not adequate; poor response or no response to the questions posed.
- 0--does not attempt problem, or conceptual understanding totally lacking.

Student-learning gains will also be assessed using the "Student Assessment of Learning Gains" website (http://www.salgsite.org) developed by The National Institute for Science Education (NISE). Students will complete the survey online and statistics of students' responses will be provided. A questionnaire is currently being developed based upon the course activities and themes identified from the SGID to examine how specific aspects of the course are helping students learn.

The most significant change will be the addition of a lecture component to the laboratory. The lecture time will provide more time within the course to provide background information to explain the lab and expand upon how the lab integrates into the current field of biotechnology. In addition, the lecture time will help facilitate more class discussion time and the addition of student presentations to strengthen student group activities. Finally, guest seminars will be incorporated to allow the students to interact with professionals currently employed within various realms of the field of biotechnology.

Dr. Kari Clase is an Assistant Professor in the Department of Industrial Technology, with a courtesy appointment in the Department of Agricultural and Biological Engineering at Purdue University.

References

Abraham, S. (2004). The Bush Administration's approach to climate change. *Science 305*, 616-617.

Annual Energy Outlook 2006 with Projections to 2030 (Early Release) – Overview. Energy Information Administration. Retrieved January 31, 2006. http://www.eia.doe.gov/oiaf/aeo/table1.html

Bell, J. E. (2009) *Vision and Change in Biology Undergraduate Education.* ASBMB Today January: 22-23

BIO-RAD Biotechnology Explorer Program (n.d) *Inquiry-based biotechnology curriculum, kits, equipment and supplies.* Retrieved March 1, 2009 from http://www.explorer.bio-rad.com

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

Campbell, A. M. (2004). Open access: A PLoS for education. *PLoS Biology. 2*(5): e145.

Clark, J., & Redmond, M. (1982). *Small group instructional diagnosis.* (ERIC Ed. 217954). Seattle: University of Washington, Department of Biology Education.

College of Technology Strategic Plan [COT]. (2003-2007). Retrieved February 24, 2009 from http://www.tech.purdue.edu/publications/index.cfm

Commission on Life Sciences [CLS]. (2000). *Biobased industrial products: Research and commercialization priorities.* Washington, DC: National Academies Press.

Emert, J., & Parish, C. (1996). Assessing concept attainment in undergraduate core courses in mathematics in Banta. T. Lund, J., Black, K., & Oblander, F. Eds., *Assessment in practice: Putting principles to work on college campuses.* San Francisco, Jossey-Bass. (pp. 104-107).

Fox, M, & Hackerman, N., & Committee on Recognizing, Evaluating, Rewarding, and Developing Excellence in Teaching of Undergraduate Science, Mathematics, Engineering, and Technology (2003) Evaluating and improving undergraduate teaching in science, technology, engineering, and mathematics. Washington, DC: National Academies Press

Fox, M. A. (2003). Pan-Organizational Summit on the U.S. Science and Engineering Workforce: Meeting Summary. Washington, DC. National Academies Press.

Herrara, S. (2004). Industrial biotechnology—A chance at redemption. *Nature Biotechnology.* 22:6. pp. 671-675.

Kling, J. Careers in biotech manufacturing. *Science's Next Wave,* April 23, 2004. Retrieved March 30, 2009 from http://sciencecareers.sciencemag.org/career_magazine/previous_issues/articles/2004_04_23/noDOI.2878137249415052115

Littlehales, C. (2004). Industrial biotech takes center stage at World Congress in 2004. *Biotechnology Industry Organization* Accessed March 2007 http://www.bio.org/worldcongress/media/20040426.asp

Mervis, J. (2008). Going from RAGS to riches proving to be very difficult. *Science.* 320: 728-729.

National Research Council [NRC] (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: National Academies Press.

Pacala, S. & Socolow, R. (2004). Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. *Science, 305,* 968-972.

Pearson, G., & Young, A. Committee on Technological Literacy, National Academy of Engineering, National Research Council (2002) *Technically speaking: Why all Americans need to know more about technology.* Washington, DC: National Academies Press

Socolow, R. H. (2005). Can we bury global warming? *Scientific American, 293*(1), 49-55.

Singer, S., Hilton, M. & Schweingruber, H. (2005) *America's Lab Report: Investigations in High School Science.* Washington, DC: National Academies Press.

U.S. Department of Energy (DOE), Office of Science, Office of Biological and Environmental Research, and Office of Advanced Scientific Computing Research. (2005). *Department of Energy Genomics: GTL Roadmap: Systems Biology for Energy and Environment.* Accessed March 2007 at http://DOEGenomesToLife.org

STEM-Based Computational Modeling for Technology Education

Aaron C. Clark and Jeremy V. Ernst

Abstract

According to professionals in education, change is an ever-present and evolving process.With transformation in education at both state and national levels, technology education must determine a position in this climate of change.This paper reflects the views on the future of technology education based on an ongoing research project. The purpose of the project is to show a contemporary view of one direction that technology education can take for providing 21st century skills and learning to students.

Change in Technology Education

Over the years, the technology education profession has experienced several changes in the content taught and the way the field is presented. From the manual arts movement to the Jackson Mills Project, change and the ability to refocus curricula has been central to the identity of the technology education profession. One of the reasons students and society benefit from modernized technology education is because of its willingness and ability to anticipate and identify necessary change (Gomez, 2001). Computational modeling is one example of contemporary technology that can be taught in the classroom and allow students to acquire 21st century skills. This capability to identify areas of change, allows the profession to grow and take on new endeavors that have resulted in the discipline remaining contemporary (Partnership for 21st Century Skills, 2004).

The current trends in education that are related to the discipline include areas of integration, academic accountability, and a variety of literacies (Partnership for 21st Century Skills, 2004). Although educators in the field have embraced a need for technological literacy, associated standards, and the integration of content in the areas of science, technology, engineering, and mathematics (STEM), few have evaluated the role in the No Child Left Behind Act (U.S. Department of Education, 2007a), the President's Information Technology Advisory Committee (PITAC) Report (National Coordination Office for Networking and Information Technology Research and Development, 2007), or the new Perkins Act (U.S. Department of Education, 2007), and what impact the initiatives have on the future. The intent of this paper is to define the authors' views on the direction of technology education for the next 10 years.

Current Changes in Technology Education Curriculum

Looking into skills for the 21st century, authors Murnane and Levy (2004) stated that for the United States to remain globally competitive, new skills such as expert thinking and complex communication need to appear in curricula at all levels. Expert thinking addresses abilities, such as critical thinking skills and creativity, required to solve problems outside traditional frameworks. Complex communication addresses the need to have students breakdown information and communicate in different forms and in a variety of ways to a diverse set of audiences.

Considering the competencies outlined by Murane and Levy (2004), how can technology educators, during the next 10 years, bring expert thinking and communication skills into the classroom? The authors of this paper suggest focusing on a national technology education curriculum that can transform the discipline to include engineering, design, and computational science (i.e. computation modeling) as new areas of study underneath the broader umbrella of STEM education. Engineering, design, and computational science, through the study of technology, will permit the use of higher order thinking skills, the integration of academic areas, and the placement of a broader focus in areas needed for future economic growth in the United States.

Engineering education can be used to bring about career awareness for those students wishing to become professionals in engineering- and technology-related disciplines or as a way to link physical sciences to technology for real-world understanding (Varnado & Pendleton, 2004). Modeling, testing, analysis, and simulation could all be major components of this type of technology education curriculum. The study of engineering, through a course for all students or a course for those wishing to pursue engineering as a career, helps address expert thinking, established by Murnane and Levy (2004).

Design concepts also can be easily integrated to address expert thinking and particularly, complex communication. Although design has been a part of the technology education curriculum since its beginning, only with the development of the Standards for Technological Literacy (STLs) has it come to the forefront. The authors suggest that during the next 10 years, technology educators should find a unique way to present design through the study of technology. One suggestion would be to not solely concentrate on traditional areas within design education, but to classify design into three categories that can be easily supported by the STLs. Design curricula could present information as related to three worlds: micro, human, and macro.

The micro world would use design to problem solve and reconstruct at the level that is normally invisible to the human eye. This would allow for the inclusion of scientific concepts (i.e., nanotechnology and areas of biotechnology and biometrics) involving data-driven simulations. The human-built world is where most professionals see design components being positioned. Design at this level includes a variety of areas of problem solving, including re-engineering a variety of devices for improvement. The human-built world of design could include, but not be limited to, the traditional areas of graphic and industrial design. Finally, the macro world, within a 21st century design curriculum for technology education, would include the architectural, civil, and transportation areas. This would encompass the study of civil structures, environmental design, and community planning (International Technology Education Association, 2005).

Changes to existing national curricula focused on technology education are currently being defined by the profession and may become a part of technology education within the next 10 years. But what can be done to address the two skills of expert thinking and complex communications as a collective unit? How can the professionals in the area of Technology Education address the current problems of high dropout rates, teaching 21st century skills to all students, and bringing relevance to the classroom? Additionally, what roles do expert thinking and complex communications play in technology education? The authors of this paper believe that the inclusion of computational science will assist in addressing issues related to drop-out rates and 21st century skills.

Computational science, as defined in this paper, comes from the extensive research conducted for the development of a new scope and sequence for technology education in North Carolina. Computational science within technology education will aid in the integration and enhancement of STEM-based education. The National Coordination Office for Information Technology Research and Development sponsored a presidential taskforce to look into 21st century skills. A product of this taskforce was the establishment of the President's Information Technology Advisory Committee (PITAC). The PITAC (2005) defines *computational science* as the ability to arrive at solutions to real-world problems through computing applications. This definition further includes areas of modeling, simulation, computer science, information science, and computing infrastructure to support areas of science and engineering in solving problems. Members of the PITAC consider this area as a multidisciplinary approach to addressing 21st century challenges, and thus view visualization as a key to complex communication across disciplines.

Considering this definition and all the components associated with the report, the authors of this paper determined that computational science would be the next area for study at both the state and national levels. Computational science at the secondary level includes the use of multidisciplinary approaches to learning (i.e., STEM integration), tools (i.e., computers), and techniques (i.e., real-world scenarios) that can attract students, especially those deemed at risk for dropping out of school. *At-risk students* are defined, in this paper, as "students whose economic, physical, emotional, or academic needs go unmet or serve as barriers to talent recognition or development, thus putting those students in danger of underachieving or dropping out" (National Association of Gifted Childeren, 2008, ¶ 8).Computational science will allow for the integration of science and technological literacy to occur though the study of visualization and the development of both virtual and physical models. This definition was developed so that true STEM integration could occur in the technology education classroom at the same time that 21st century skills for students taking technology education courses are being developed. The authors believe that this new area will be important as technology educators try to reach and support both state and federal initiatives while maintaining the intended focus: t echnological literacy for all.

STEM in the Curriculum

Hevesi (1999, 2007) reports on a research study conducted by the Comptrollers Office in the City of New York that identified three major skill and knowledge indicators of workforce success after high school: (1) mathematics competency, (2) science competency, and (3) technological competency. Hevesi indicated that students are poorly prepared, academically, in mathematics and science in early grades, hampering knowledge growth in advanced mathematics and science courses in later educational endeavors. Hevesi (2007) also indicated a teacher training shortage in mathematics and science disciplines. An evaluation of the findings from the study led to the recommendation of integrated content across science, technology, and mathematics with a supportive teacher professional development structure.

Considering this need to bring about STEM and the different competencies needed for the future workforce, the authors of this article began the process of developing a STEM model for technology education that would address Murnane and Levy's (2004) two central skills, expert thinking and complex communication. The skills need to be addressed in such a way that supports initiatives important to the state and nation. This would include working with students deemed at risk for successful completion of end-of-grade tests for academic areas. Given that engineering and design are already established areas of study, researchers and educators in North Carolina wanted to see how computational science could be used to educate at-risk students, while bringing about technological literacy. Research has already been conducted on design and engineering education for secondary education, but none had been used to investigate computational science as defined in this paper. Therefore, the group set out to find a way to integrate STEM into the technology education classroom through the area of computational science.

The initial investigation included computational science fundamentals and relied on a companion course structure with a full theoretical foundation. This model became too complex, and teachers lost focus and were unable to achieve the collaboration necessary for the model to serve as an effective educational approach. The researchers decided that a supplemental companion approach, as opposed to an integrated companion approach, would be easier to implement. Such a supplemental approach targets specific academic content, whereas the integrated approach spans multiple core areas simultaneously. The research described in the next section was conducted for the development of a STEM-based curriculum for technology educators in North Carolina; as it also illustrates the demonstration of power that computational science can have on the future of technology education worldwide.

The North Carolina STEM Project: A Future Model for Technology Education

The North Carolina STEM project (NC-STEM), sponsored by the North Carolina Department of Public Instruction Career and Technical Education division and North Carolina State University, was designed to aid in the endeavor to keep at-risk high school students in school. The project gave students additional help in the areas of mathematics and science (which required a passing grade for graduation) using career and technical education (CTE) content and proven pedagogical methodologies such as kinesthetic learning applications and problem-based learning (Stone & Alfeld, 2004). The NC STEM project evolved from research developed during the past decade that had influenced the development and funding of curriculum projects such as the Scientific and Technical Visualization curriculum and the National Science Foundation instructional materials development project titled, "VisTE: Visualization in Technology Education" (Clark, Wiebe, Petlick, & Ferzli, 2004).

With North Carolina's need to improve its drop-out rate, the integration model was applied to core academic areas using methods and content from CTE for piloting and further developing NC-STEM. Note that most models include the integration of academic areas (science, technology, and mathematics) focusing on higher cognitive understanding that lead toward the advanced understanding of engineering, science and related STEM careers (Brown, 2003). This project was designed to use previously described integration fundamentals with those students who were at risk of dropping out of school, not with the academically gifted.

The researchers of this project believed by making required academic materials relevant to students deemed at risk of failing and dropping out of school, they were more likely to understand the content and pass the end-of-grade tests and therefore stay in school and graduate. Although myriad academic courses exist, the researchers felt that the first two courses that demanded this type of development and work were algebra and biology, since passing grades in both are required for graduation in North Carolina, as well as in other states (Reddick, Jacobson, Linse, & Yong, 2007).

The project began in academic year 2005-2006 with the development of a theoretical framework that included the teaming of academic subject teachers with those in CTE (mainly teachers in technology and graphics education). Teachers were to work together to develop and test materials that both academic and technical teachers could use in the classroom to enhance fundamentals in biology and algebra. They were asked to focus on areas within the state curriculum where academic subject area teachers identified a lack of student understanding. Three pilot sites were selected within the state, all representing a population of at-risk students within their school deemed appropriate for this project. Due to lack of teacher understanding, misaligned pacing guides, and inadequate time to cover requirements in the academic course, this first try was a failure. Further investigation was predicated on the observations made from the prior project, where preliminary exploration within computational science took place.

STEM Companion Model

In the academic year of 2006-2007, the researchers decided not to continue with the above-mentioned model. Given their collective experiences and through a careful review of additional literature in the field, the researchers decided to develop a new theoretical model that would fully capitalize on Computational Science in an applied manner (Cushman, 1989). It was taken into considering how the PITAC report could be applied in secondary education; this new model would focus on literacy within science, mathematics, and technology, as well as the visual and kinesthetic learning associated with CTE areas, especially technology education. This model was still focused on the two required courses of algebra and biology, and it also incorporated pedagogical methodologies brought forth by CTE. The model also required that a course be made for each academic subject in question (i.e., one for algebra and one for biology).

The companion courses were designed to use a "hands-on" approach to learning, having students use both virtual and physical modeling in the process. The researchers decided not to focus on the academic course competences, but instead focused on major topic areas in the "end-of-grade" exam that students have difficulty with as indicated by teachers and statewide statistical data (Public Schools of North Carolina, 2007).

Considering this new model, the researchers met with teachers, administrators, and pilot test sites throughout the state to decide on an initial plan of action. From the meetings, a model was developed and piloted in two field sites. This new STEM companion model required at-risk students to not only take the required academic courses but also to take CTE-based companion courses at the same time to further develop their knowledge in that subject matter and focus on areas of difficulty. Students in the course who were deemed not at risk were not required to take the companion course.

The companion courses are not designed to replace the existing academic course, but to compliment the required knowledge and provide students with additional time, activities, and different methods of learning for obtaining the essential information. During this research, it was decided to focus only on one course. Algebra I was selected because it was identified as a major stumbling block for students statewide.

The researchers began the process by finding teachers in both the academic area of mathematics and in CTE areas of technology education and graphics to develop this new companion course for Algebra I (Public Schools of North Carolina, 2007). Teachers were charged with the identification of problem areas for most students in Algebra I, and from this they developed virtual and physical modeling activities that could help students better understand the identified areas. Mathematics and CTE teachers identified the following areas as those with witch students need the most help:

- Rational numbers
- Irrational numbers
- Geometric patterns and equations
- Interpreting graphs and using formulas for interpretation
- Understanding ratios
- Slope
- Quadratic equations with outputs
- Understanding exponential functions
- Using formulas to solve problems pertaining to exponential functions and analysis

Activities to teach the identified topics included the use of computer-aided design, web-based gaming applications, and developing PowerPoint Presentations. Instructional activities that involve modified board games and electronic games, such as Battle Ship and Sudoku, projects, such as rubber band/mousetrap cars, and maglev trains, were used to further engage students. It was believed that students would not only see the relevance of algebra in their everyday lives, but also would enhance their computing skills in areas of CAD, illustration, electronic presentation, and spreadsheet software. Students further develop visual skill in using both 2D and 3D graphics as a way of communication, while content understanding is enhanced through developing static and dynamic models.

During the ongoing evaluation process of the Algebra I companion course, the Biology I curriculum for the STEM project began its initial development through the already existing CTE curriculum, called Scientific and Technical Visualization I and II. This second biology-based curriculum for the project should require less modification since most of the content already exists within the CTE Scientific and Technical Visualization curricula currently being taught under the technology education scope and sequence. However, expertise is needed to extract the biology content from curricula and add new activities for those areas within the academic course of Biology I that are not represented well in the Scientific and Technical Visualization curriculum. Initial development of this curriculum change took place during the 2008-2009 academic year, with the prospect of piloting this companion course for Biology I during the 2009-2010 academic year.

This STEM-based project must first be accepted by professionals in the fields of CTE and technology education. The researchers would like to see this project expand not only to other states, but also into additional courses in both mathematics and science. Suggested courses for this type of companion course development would include Algebra II, Geometry, Earth and Environmental Science, and Chemistry, just to name a few identified by the research conducted within this project (see Figure 1). The authors of this article believe that by including the proposed STEM courses under the area of computational science and including engineering and design, the two skill sets needed for the 21st century as indicated by Murnane and Levy (2004) will have been met.

Overall, this is a "win-win" scenario for all involved. Students get a chance to take additional courses that further establish relevance of academics while gaining valuable computing skills. Academics get a "boost" within the accountability movement, and teachers perhaps experience less classroom management problems because of heightened student engagement.

In addition, there is the potential for more students to pass their courses and stay in school. More students complete a sequence of CTE courses, increasing its ability to address the drop-out problem plaguing most schools. With the current focus for education on academics,

Figure 1. Proposed Courses for Computational Science to be Included in the Curricular Scope and Sequence

Mathematics Model	Technology
Algebra I	Virtual & Physical Modeling – Algebra I
Algebra II	Virtual & Physical Modeling – Algebra II
Geometry	Virtual & Physical Modeling – Geometry
Science Models	Technology
Biology	Scientific Visualization – Biology
Earth & Environmental Science	Scientific Visualization – Earth & Environmental Science
Physical Science	Scientific Visualization – Physical Science

this allows CTE to play an equal role in the education of students. Curriculum development should show that STEM and the integration model proposed nationally can be highly effective, indicating that STEM is not just for the academically gifted students; it can be used to help a significant portion of students understand relevance, accept rigor, and pass end-of-course tests. There are several additional reasons why this project should be implemented at the national level through technology education. The first two are its timeliness and its imperative need. At no time in recent history has there been more concern voiced (by policy leaders, practitioners, and citizens) for acting on the problems that call for high school reform. By developing curricula offered as companion courses to academic courses taught in every high school, schools will not be required to implement major changes in course offerings. However, adopting this project's strategies will entail a major change in the way science, technology (applied engineering), and mathematics education programs are offered. Also, the project addresses the spirit and intent of the national No Child Left Behind legislation—serving all children well by providing an education that enables them to become responsible, contributing, and participating citizens.

A National Need for Computational Science to be Taught in Technology Education; beyond Engineering and Design

The President's Information Technology Advisory Committee wrote: "Computational Science—the use of advanced computing capabilities to understand and solve complex problems—has become critical to scientific leadership, economic competitiveness, and national security. The membership of the PITAC believe that computational science is one of the most important technical fields of the 21st century because it is essential to advances throughout society" (p. iii). The report continued: "Global competitors are increasingly testing U.S. preeminence in advanced R&D and in science and engineering-based industries" (p. 7). Further, the PITAC stated: "We are now at a pivotal point, with generation-long consequences for scientific leadership and economic competitiveness if we fail to act with vision and commitment" (p.18).

The authors of this article are proposing to expand the current technology education program by adding at a minimum one science-based and one mathematics-based course and preferably two science-focused and three mathematical-focused courses. Beyond the argument offered by the PITAC, there are two other courses directly related to CTE's and technology educators' mission at the national level. The first argument is predicated on the new Perkins Act and pedagogical theory; the second, on experiences learned while implementing the NC-STEM Project over the past two years.

First, the new Perkins legislation requires CTE to take greater responsibility in helping students understand and apply academic concepts. The companion course structure clearly assists in the application of academic concepts. The pedagogical assumption is that STEM strategies make sense and work. For the purpose of this proposal, a STEM project is defined as the integration of three curricula: science, technology (encompassing engineering at the K-12 level) and mathematics. STEM is essentially an integration strategy. There is ample research evidence indicating curriculum integration is effective, although more difficult to implement at the high school level.

The second argument is more practical and comes from lessons learned through the NC-STEM Project. The initial idea for NC-STEM was to serve a cohort of students who would be concurrently enrolled in math, science, and technology (Scientific and Technical Visualization) courses. Integrated activities would be created which would incorporate concepts and principles from each of the three areas. The idea seemed to make sense, but turned out extremely difficult to put into practice. Therefore, a simpler strategy of pairing two courses together as companion courses, rather than trying to link three courses, made for a more focused approach. Designing companion Scientific and Technical Visualization courses for a particular science such as biology makes it easier to stay focused on the specific essential science ideas. Further, companion courses enable administrators to sequence the course to reflect the sequencing used in science programs.

This same argument was the rationale for the proposal of the Mathematical Modeling and Analysis sequence. However, there is a difference between the science and mathematics computational sequences in that the computational mathematics courses are structured to heavily incorporate physical modeling where the computational science sequence relies primarily on virtual modeling.

While STEM strategies serve both gifted and at-risk students well, the Computational Science Program would permit academically struggling students to apply simple and complex modeling tools to better understand science, technology, engineering, and mathematics concepts and principles. It is expected that the strategies incorporated in this program will make for increased understanding possible for students who would otherwise fail to reach a high degree of technical and academic attainment in traditional settings. The computational science courses are meant to be taken as companion courses, but do not have to be as long as students have the academic area reinforced at some given point.

Conclusions and Recommendations

Reflected in this article are the collective views of the authors as they consider the future of technology education for the next 10 to 20 years. Technology education is yet at another crossroads with its professional interests and associations. Currently, technology educators have embraced engineering and design as core concept. The authors conclude that as long as the concepts taught within the new core areas reflect best practices and technological literacy for all students, from the gifted students to the students at risk for failing, success will (for most students) follow through integration brought about by STEM.

The authors believe that technology education can work in collaboration with engineering groups so that all students can gain from taking a class in technology education. As educators prepare students to be expert thinkers in the 21st century, they must keep in mind that the study of engineering and the overall applied concepts that can come from this area can be appropriate for most students. Further, design processes are also major contributors to students' understanding of products and sequences. By establishing design as a study within the micro- , human- , and macro-built worlds, students will learn all facets associated with these products and processes and will have a better understanding of the role design plays in several disciplines outside of traditional graphic arts. Design processes can serve as the integrator and driving force behind curriculum development targeting complex communication.

The area of computational science incorporates a truly new way of seeing what technology education can do to support both state and federal initiatives in education. By having courses that link science and mathematics to technology through the development of both virtual and physical models, STEM content integration can take place for students. CTE also is at a crossroads; the future of CTE may not be the traditional training of more automotive technicians, cabinetry makers, or cosmetologists, but the enhancing and support for academic areas using the established pedagogy that works well with students.

Overall, the future of technology education is yet to be determined and no one can forecast with certainty the course of direction. It is the belief of the authors of this article that provided the current educational climates; technology educators must demonstrate how they can enhance learning of academic areas centered on technological literacy needed for the 21st century.

Note: This paper was presented at the 94th Mississippi Valley Technology Teacher Education Conference in Rosemont, IL

Dr. Aaron C. Clark is an Associate Professor of Technology, Engineering and Design Education at North Carolina State University in Raleigh, and is a member of the Alpha Pi Chapter of Epsilon Pi Tau.

Jeremy V. Ernst is an Assistant Professor in the Department of Mathematics, Science, and Technology Education at North Carolina State University in Raleigh, and is a member of the Gamma Tau Chapter of Epsilon Pi Tau.

References

Brown, B. (2003). The benefits of career and technical education: Trends and issues alert. Office of Education Research and Improvement, Washington, DC. ED 481 326.

Clark, A. C., Wiebe, E. N., Petlick, J., & Ferzli, M. (2004). VisTE: Visualization for technology education; An outreach program for engineering graphics education. Proceedings of American Society for Engineering Education, Southeast Section. Gainesville, FL.

Cushman, K. (1989). Asking the essential questions: Curriculum development. Horace, 5(5). 17-24.

Gomez, A. G. (2001). History and philosophy of technology education: Technology education time-line university of wisconsin-stout. Retrieved December 28, 2008, from http://www.imagine101.com/title.htm

Hevesi, A. G. (March 2, 1999; October 16, 2007). Schools lack math and science needs. New York Times.

International Technology Education Association (ITEA, 2005). Technology for all americans project. Retrieved October 16, 2007, from http://www.iteaconnect.org/TAA/ TAA.html

Murnane, R. J. & Levy, F. S. (2004). The new division of labor: How computers are creating the next job market. Princeton, NJ: Princeton University Press.

National Association of Gifted Children (NAGC, 2008). Glossary of gifted terms. Retrieved December 27, 2008, from http://nagc.org

National Coordination Office for Networking and Information Technology Research and Development (2007). Your federal networking and it r&d resource. Retrieved October 15, 2007, from http://www.nitrd.gov/

Partnership for 21st Century Skills (2004). U.S. students need 21st century skills to compete in a global economy. Retrieved October 15, 2007 from http://www.21stcenturyskills.org/index.php

President's Information Technology Advisory Committee (PITAC, 2005). Report to the President on computational science: Ensuring America's competitiveness. Washington, DC: U.S. Government Printing Office.

Public Schools of North Carolina (2007). Accountability services. Retrieved October 15, 2007, from http://www.ncpublicschools.org/accountability/

Reddick, L. A., Jacobson, W., Linse, A., & Yong, D. (2007). An inclusive teaching framework for science, technology, engineering, and math. In M. Ouellett (Ed.), Teaching inclusively: Diversity and faculty development. Stillwater, OK: New Forums Press.

Stone, J. R. & Alfeld, C. (2004). Keeping kids in school: The power of CTE. Techniques, 18(3), 28-29.

U. S. Department of Education (2007a). Reauthorization of no child left behind. Retrieved October 15, 2007, from http://www.ed.gov/nclb/landing.jhtml

U. S. Department of Education (2007b). Office of vocational and adult education. Retrieved October 15, 2007, from http://www.ed.gov/about/offices/list/ovae /index.html?src=mr

Varnado, T. E., & Pendleton, L. K. (2004). Technology education/engineering education: A call for collaboration. Proceedings of the International Conference on Engineering Education. Gainesville, FL.

Utilizing Job Camera Technology in Construction Education

Richard D. Bruce, David W. McCandless, Chuck W. Berryman, and Shawn D. Strong

One of the toughest hurdles to overcome in construction education is the varying levels of construction field experience among undergraduate students. Although an internship is a common construction management requirement, it is often completed after students complete classes in planning and scheduling. This poses a challenge for the modern construction educator concerning course design. If the instructor begins discussing activities that the inexperienced student has never been a part of, these students could fall behind their classmates. This article presents a technique for overcoming this challenge. Two-term project assignments required undergraduate planning and scheduling students to view several progress photos using current "Job Camera" technology to identify and sequence activities. A survey was administered to three semesters of students exposed to the teaching technique in order to assess the students' ability to identify and sequence activities before and after being exposed to the teaching technique. Survey results indicated that 88 percent of the respondents reported an improvement in the ability to both identify and sequence activities. Further analysis included a comparison of program exit assessment scores for students exposed to the technique versus those not exposed. A one-way analysis of variance (ANOVA) indicated that those exposed to the technique had significantly higher planning and scheduling scores than those who were not exposed to the Job Camera technology.

Introduction

Proper planning and scheduling is the key to a successful construction project (Glavinich, 2004). Realizing the need to provide effective planners and schedulers to industry, many construction education programs require a course in construction planning and scheduling. The American Council for Construction Education (ACCE), recognized by the Council for Higher Education as the accrediting agency for four year baccalaureate degree programs in construction management, requires 3 credit hours of planning and scheduling (ACCE, 2009).

Many construction planning and scheduling authors (Glavinich, 2004; Hinze, 2008; Mubarak 2005) focus on the creation and use of the Critical Path Method (CPM). In order to prepare a network following CPM it is necessary to identify and sequence activities (Hinze, 2008). In fact, according to many CPM authors (Patrick, 2004; Hinze, 2008), these are the first two steps in creating the network model.

Statement of the Problem

Construction educators (McManus, Songpiriyakij, & Ryan, 2006; Mattila, Pocock, & Suermann, 2006), have previously noted that the topic of planning and scheduling is difficult to understand for students without practical construction experience. More specifically, it is difficult for inexperienced students to identify and sequence activities without a frame of reference. This poses a challenge for the modern construction scheduling educator concerning course design. If the instructor begins discussing activities that the inexperienced student has never seen, the student may fall behind classmates.

To offset this problem, Job Camera technology was incorporated into the lead author's planning and scheduling course to bring the students to a common ground of understanding concerning construction field operations. The next few paragraphs detail modern Job Camera technology and how it was incorporated into the instructor's construction scheduling course through two term project assignments.

Modern Job Camera Technology

Modern Job Camera technology enables students to study the construction of entire projects one photograph at a time. A remote camera placed at the jobsite transmits high-resolution photographs through a cell tower to a central data center, where they are archived and placed on a server. Students are then able to access the photographs from any computer that has an internet connection. The user is able to jump around to different photographs in the archive by clicking on different calendar days and selecting different times of the day. Another feature allows the user to zoom in to a portion of the photograph and hold that zoom while advancing the photographs. This allows the viewer to concentrate on the same area for multiple photographs. These advanced interface functions separate the use of Job Cameras from mere banks of photographs or time-lapse videos.

Incorporating Modern Job Camera Technology into a Planning and Scheduling Course

The term project in the lead author's planning and scheduling course was a semester-long project that incorporated and applied class material as it was assimilated by the students. The primary text used for the course was *Construction Project Planning and Scheduling* by Charles Patrick (2004). The term project followed Patrick's basic steps in creating a network model, including defining activities, putting activities in order, diagramming the activities in network format, determining activity durations, and calculating the schedule. The term project followed the remainder of the course that included creating a cost distribution graph, allocating resources, and scheduling the project using scheduling software. Appendix A details the term project assignments and describes their point values.

The first term project assignment required the students to visit the provided project website, view the available pictures, and identify fifty construction activities. Students were encouraged to search the Internet for other project pictures and information. These sites explained the affect on the community and provided secondary project information, such as the actual milestone schedule and budget information. The Four Bears Bridge website provided by the North Dakota Department of Transportation (NDOT) and the Oxblue Corporation, for instance, included historical photographs of the previous two bridges. These photographs provided the Fall 2005 students with a feel for construction methods and improvement that had been made in construction technology during the many ensuing years. Figure 2 below shows the sheet piling that had to be installed before concrete could be poured in pier 2 of the previous bridge in 1955. Figure 3 shows the constructor's modern day approach where a concrete cofferdam was formed and poured on a barge at the shore before it was transported to its final location.

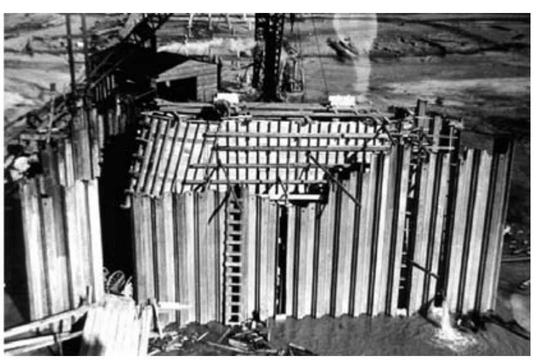


Figure 2: Pier 2 of the second Four Bears Bridge in 1955 (NDDOT, 2005)

Figure 3: Pier 3 of the third Four Bears Bridge in 2004 (NDDOT, 2005)

This first term project assignment forced students to narrow vast quantities of information gathered from the pictures into activities of two or three words, following the verb plus subject format instead of entire sentences. Students also had to decide the level of detail and how they would be consistent throughout the 50 activities. Upon collecting and discussing the first list of 50 activities with the students, the instructor provided a common list of activities for each student. This list contained as many of the students' original activities as possible so they would take ownership of the list. The left column of Appendix B includes 24 of the 50 activities the students created after viewing photographs of the Four Bears Bridge project.

The second term project assignment required the students to provide 1-3 activities from the original 50 activities that immediately preceded each of the activities. The right column of Appendix B shows the activities that immediately preceded the original activities. Like many scheduling and project management authors (e.g., Mubarak, 2005; Stevens, 1990) the instructor used activity and immediate predecessor activity (ACT/IPA) charts to teach logic. Given the list of activities already agreed upon, the student filled in the predecessors to each activity. This assignment required the students to return to the Job Camera photographs to determine the contractor's sequence of events.

Figures 4-6 show three screen shots of the Four Bears Bridge using the Oxblue Corporation's Job Camera interface (2005).

Figure 4 below shows a pier location that is about to receive its cofferdam base. Figure 5 shows the same location a day later at the same time.

If the student just clicked through the photographs by day, he or she would see the cofferdam suddenly appear somewhere between these two days. However, because these photographs

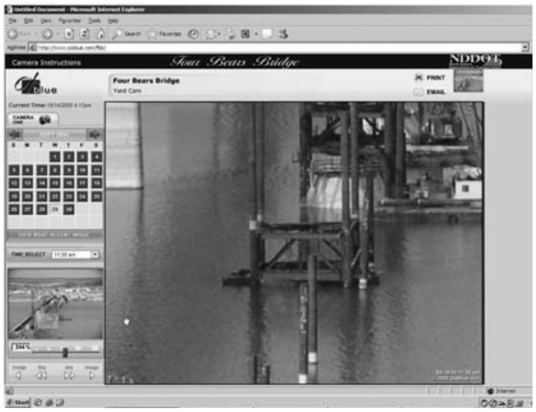


Figure 4: Four Bears Bridge photograph taken 9/29/04 at 11:06 am (Oxblue Corporation, 2005).

Figure 5: Four Bears Bridge photograph taken 9/30/04 at 11:05 am (Oxblue Corporation, 2005).

Figure 6: Four Bears Bridge photograph taken 30 September 2004 at 9:10 am (Oxblue Corporation, 2005).

were taken every ten minutes on this project, the student was able to pull up 9:10 am on September 30 to see a boat pushing a barge and cofferdam base into the proper location (see Figure 6).

At the end of term project assignments 1 and 2, the students turned in a table similar to the one in Appendix B. Even though students may have referred back to the pictures to identify activity durations, the remaining term project assignments did not specifically require the students to use the Job Camera technology.

As one can see in the preceding paragraphs, the first two term project assignments required students to utilize modern Job Camera technology to study sequentially archived construction photographs to identify and sequence activities. The goal of the term project assignments was to provide a frame of reference for discussion of activities and their sequencing by students with no construction experience and those with years of construction experience.

Literature Review

No studies were found on the efficacy of incorporating Job Camera technology into construction education curriculum. This literature review, therefore, focuses on incorporating technology in the classroom in order to engage students. It was written by David McCandless who holds a doctorate in education.

The ability to adjust and change is a key element to the success of the learning organization. This is asserted by Schein (1996) who stated that the ability to adapt is central to the learning organization's health, and it was substantiated by Senge (1990) who pointed out that the successful learning organization must emphasize an increased ability to adapt. As new organizational learning takes place, Mezirow pointed out that adaptations and changes in knowledge become apparent to the organization and to remain successful the faculty must use critical reflection to see how to turn this new transformative knowledge into a more inclusive, discriminating, permeable, and integrative perspective (as cited in Merriam, 2001; as cited in Scribner, & Donaldson, 2001).

Russell (2000) stated visual electronic media have not affected our classrooms to the same extent that they have affected students in society. Therefore, he argues visual information from the superhighway and other multimodal media being used in the classroom is long overdue. Through the use of Job Camera experience, students can begin to visualize the construction and scheduling experience in a real-world setting and as stated by Pinsky and Wipf (2001) significantly increase recall and retention while enhancing the value of the learning experience.

This new knowledge base must be transformed so it can be shared with students through a constructive, re-acculturated language and cooperative and collaborative learning (Bruffee, 1999). As Bruffee pointed out, most students want to learn, and one of the best ways to accomplish this is by putting the students into a healthy environment or transition community where the students can talk with each other and work together.

As the educational leader begins to understand and use new concepts, the students become motivated and realize they play a part in the learning process. As Weimer (2002) pointed out, "If students are engaged, involved, and connected with a course, they are motivated to work harder in that course, and we know from so many studies that time spent on task results in more learning" (p. 31).

Purpose of the Study

Although the lead author who carried out this research perceived the Job Camera technology to be useful and effective in engaging students and leveling the field in regard to construction experience, he did not have any empirical evidence that it positively affected the students. The purpose of this study was to determine whether the use of Job Cameras increased the construction management students' ability to identify and sequence activities. The research question was as follows: Does the Job Camera technology increase the construction scheduling student's ability to identify and sequence activities?

Research Questions

In order to answer the above substantive research question, the following two research questions and hypotheses were created:

1. Is there a difference between the percentage of activities the students could identify and sequence before studying the Job Camera photographs versus after studying the Job Camera photographs?
2. Is there a statistically significant difference in the mean AC planning and scheduling scores for students exposed to the technique versus those not exposed?

Hypotheses

1. The null hypothesis is that there will be no difference between the percentage of activities the students could identify and sequence before studying the Job Camera photographs versus after studying the photographs.

2. The null hypothesis is that there will be no statistically significant difference between the mean AC planning and scheduling scores for students exposed to the technique versus those not exposed.

Methodology

Research Design and Population

In order to address whether the Job Camera technology and teaching technique had an effect on the students' ability to identify and sequence activities, the instructor employed two research designs in the study. The first research design (phase 1) utilized survey research to compare student perceptions on their ability to identify and sequence activities before and after viewing the Job Camera photographs. The second research design (phase 2) compared exit assessment scores of exposed students (experimental group) to non-exposed students (control group).

In the first phase, the instructor surveyed all of the students that had been exposed to the Job Camera teaching technique. Because he had been utilizing the technique for the past three semesters (Fall 2004, Spring 2005, and Fall 2005) the nonrandom sample was limited to 43 students who completed the course in those three semesters. Table 1 provides the number of the students per semester enrolled in the scheduling course.

Table 1 Sample Size by Semester for Study 1

Semester/Project	n
Fall 2004/Wisconsin Clinic	9
Spring 2005/Texas Clinic	17
Fall 2005/North Dakota Bridge	17
Total	43

In the second phase, the researcher compared a group of students that was not exposed to the technique (control group) to a group of students that was exposed (experimental group). The source for comparison was the students' planning and scheduling score on the program's exit assessment--the American Institute of Constructor's Associate Constructor (AC) exam.

The sample was all students that took the AC exam during those three semesters: Fall 2004, Spring 2005, and Fall 2005. Again, students were not randomly assigned to the groups; either they were exposed to the technique or they were not. The first phase of the study included all students in the planning and scheduling course for the three semesters. Four of those students had not taken the AC exam, four were not required to take it due to their major, one transferred before taking the exam, and one was younger than 18 years old; the number of subjects dropped from 43 to 33. Table 2 shows the sample size for the two groups: those exposed to the technique and those that were not exposed.

Table 2 Sample Size of Exposed and Not Exposed to Technique

Exposed to Technique	Not Exposed to Technique
33	45

Instrumentation

In order to determine whether the use of Job Cameras increased the construction management students' ability to identify and sequence activities, the instructor made use of two instruments. The researcher created and administered a six-question survey. Second, he researched student results on his program's senior exit exam.

For the first phase of the study, the researcher created the six-question survey titled the *Job Camera Effectiveness Survey* (see Appendix C). Because the instructor originally created the instrument to test the efficacy of the teaching technique, without consideration of future publications, the instrument was not pilot tested. Validity and reliability are addressed in the *Results* section of this paper.

The first research question addressed which semester and project the students were exposed to. The second question asked the students to choose which level of experience most closely fit their backgrounds. They were given the choice of no experience; 1 week to 3 months; 3 months to 1 year; and more than 1 year. These choices were created by the instructor based on the student's rank when enrolling in the course. The course is a sophomore/junior level course. Therefore, traditional students would have only had 2-3 summers available to work in construction prior to taking the course. The remaining questions sought to identify their ability to understand and sequence activities before versus after viewing the Job Camera photographs. The percentage thresholds that were created by the instructor follow: none; 1-50 percent; 50-75 percent; and 75-100 percent. Because most of the students were still in the program, the survey was administered in person. For students who had graduated, the survey was mailed to their last known address. The researcher limited discussion to the instructions at the top of the survey to limit the possibility of biasing the students to respond in any way and to reduce the Hawthorne effect.

For the second phase, the instrument was the AC exam. The Midwestern University has required all construction management students to take the exam since 1994. The exam tested students in ten areas, including communication, engineering concepts, management, materials, bidding, budgeting, planning & scheduling, safety, surveying, and project administration. The American Institute of Constructors provides scores in each of the areas. While many of the nation's construction management programs require students to take the exam, the lead author was not able to locate any studies on either the reliability or validity of the exam.

Statistical Analysis

For the first phase of the study, the researcher utilized the cross-tabulations (descriptive statistics) feature within SPSS version 15. This enabled the researcher to identify how many activities the students could identify before and after viewing the Job Camera photographs based on experience level.

For the second phase of the study, the researcher utilized the ANOVA to compare the means of the control group and the experimental group. An alpha of .05 was selected. The ANOVA was chosen because of the small group sizes and the fact that it is robust when small differences exist (Minium, Clarke, & Coladarci, 1999).

Data Collection Procedure

For the first phase, the instructor administered the survey to his current scheduling class first, then to students from previous semesters as he encountered them. Because most of the students were still in the program, the survey was administered in person. For those students that had already graduated, the survey was mailed to their last known address. As mentioned previously, the instructor limited discussion to the instructions at the top of the survey to limit the possibility of biasing the students to respond in any way and to reduce the Hawthorne effect.

For the second phase, the lead author gathered results of the AC exam. After each semester, the American Institute of Constructors sends an e-mail report showing a breakdown of scores per area for all students that took the exam at the instructor's school. The instructor gathered the planning and scheduling scores of students exposed to the Job Camera teaching technique and then of all other students who took the exam prior to that current date. He then placed the scores into an Excel spreadsheet prior to running the ANOVA data analysis.

Results

As mentioned previously, the six-question survey instrument for the first phase of the study was not pilot tested. Upon collecting data, however, the lead author coded the response categories numerically for questions 2-6 and ran a reliability test within SPSS. Cronbach's Alpha was measured at .803. Nunnally (1978) sets the minimum threshold at .70 to indicate reliability.

On the 6-question survey, the instructor achieved a 79 percent return rate by collecting surveys from 34 out of 43 respondents. While this is a respectable return rate for a survey, it should be noted that no attempt was made to control for non-response. Thus, it is unknown whether the results are similar for the other 7 students. Table 3 indicates that 15 out of 34 respondents (44.1%) had less than 1 year of general construction experience before taking CMgt 3355 Construction Scheduling. Of these 15 students, 10 (67%) responded that they could identify only 1-50 percent of the activities before studying the Job Camera photographs.

Table 4 indicates that 20 of the 34 respondents (59%) responded that they could identify and sequence 75 percent or more of the necessary activities to construct their project after studying the Job Camera photographs. The null hypothesis was rejected indicating that there was a difference between the percentage of students that could identify and sequence activities before studying the Job Camera photographs versus after studying the photographs.

When the lead author analyzed experience by sequencing confidence level before and after studying the Job Camera photographs, they found that the tables were identical to the previous two. In other words, the respondents provided the same responses for questions 5 and 6 as they did for questions 3 and 4.

Several of the respondents, 20 out of 34 (59%), provided additional feedback in the comment section of the survey. Most of the comments were suggestions, such as providing

Table 3. Experience by Identification Confidence Level BEFORE Studying Job Camera Photographs

			Percent of Activities Students Could Identify & Sequence BEFORE Studying Photographs				
			none	1-50%	51-75%	>75%	Total
General	No Experience	Count	0	0	0	0	0
Construction		Column %	0.0%	0.0%	0.0%	0.0%	0.0%
Experience	1 week to 3 months	Count	0	5	1	0	6
(1 sum = 3 months)		Column %	0.0%	25.0%	8.3%	0.0%	17.6%
	3 months to 1 year	Count	0	5	4	0	9
		Column %	0.0%	25.0%	33.3%	0.0%	26.5%
	more than 1 year	Count	0	10	7	2	19
		Column %	0.0%	50.0%	58.3%	100.0%	55.9%
Total		Count	0	20	12	2	34
		Column %	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4. Experience by Identification Confidence Level AFTER Studying Job Camera Photographs

			Percent of Activities Students Could Identify & Sequence AFTER Studying Photographs				
			none	1-50%	51-75%	>75%	Total
General Construction Experience (1 sum = 3 months)	No Experience	Count	0	0	0	0	0
		Column %	0.0%	0.0%	0.0%	0.0%	0.0%
	1 week to 3 months	Count	0	1	4	1	6
		Column %	0.0%	100.0%	30.8%	5.0%	17.6%
	3 months to 1 year	Count	0	0	4	5	9
		Column %	0.0%	0.0%	30.8%	25.0%	26.5%
	more than 1 year	Count	0	10	7	2	19
		Column %	0.0%	0.0%	38.5%	70.0%	55.9%
Total		Count	0	1	13	20	34
		Column %	100.0%	100.0%	100.0%	100.0%	100.0%

pictures that encompass the entire project from at least two vantage points inside and outside of the structure from the ground up.

AC Exam Results

In regard to the AC exam results, the instructor acquired the Planning, Scheduling, and Control scores of the experimental and control groups. The instructor was able to record all student scores. After placing an A next to the control group students and a B next to the experimental group students, the instructor opened the Excel file in SPSS version 15.0. Prior to running the one-way Analysis of Variance (ANOVA), the instructor tested the assumptions necessary for the technique. All assumptions were met. The independent samples were normally distributed and equally variable. High significant values for the Kolmogorov-Smirnov (.175 for the control group and .200 for the experimental group) test for normality indicated that the categories had normal distributions. Levene's test for equality of variances indicated that the groups had equal variances ($F = 2.133$, $p = .148$).

Table 5 presents the ANOVA table for AC planning and scheduling scores for the control group versus experimental group. The F value of 7.75 was significant ($p = .007$). The null hypothesis was rejected indicating that there was a significant difference between the control group and experimental group in regard to mean score on the AC exam.

Table 5 One-way Analysis of Variance for AIC Planning and Scheduling Scores by Group

Source	df	SS	MS	F
Between Groups	1	218.78	218.78	7.75*
Within Groups	76	2146.09	28.24	
Total	77	2364.87		

*$p < .05$

Conclusions

Generalization of the study was limited to construction management students at a Midwestern University. Identifying and sequencing activities are important steps in creating a network model for a construction project. It is difficult for inexperienced construction management students to perform these tasks without a frame of reference. To offset this problem, Job Camera technology was incorporated into the lead author's planning and scheduling course. This study addressed the efficacy of the teaching technique. The substantive research question asked if exposure to the Job Camera technology increased the student's ability to identify and sequence activities.

The instructor surveyed all students exposed to the technique and compared AC exam results of students exposed to those not exposed. The survey results supported the hypothesis that the Job Camera technology had a positive impact on the student's ability to identify and sequence activities. Survey results indicated that 88 percent of the respondents reported an improvement in their ability to both identify and sequence activities after studying Job Camera photographs. Although the AC exam does not specifically measure the students' abilities to identify and sequence activities, the AC exam comparisons showed that students that were exposed to the technique performed better on the planning and scheduling area of the exam than those that were not exposed to the technique.

Discussion

The findings of this research are beneficial not only to the instructor of the course, but also to all construction management instructors who teach construction scheduling. They will not only be exposed to the Job Camera technology and how it can be incorporated into a scheduling course, but will also see how results can be measured. Results of this study may be used by other construction planning and scheduling instructors to decide if Job Camera technology could be incorporated into their courses. Instructors may decide to incorporate the same methodology, or they may decide to use the same strategy for measuring results.

The authors see great potential in this area of study. In addition to providing a term project for a planning and scheduling course, the authors see potential applications in other construction-related courses, such as estimating, project administration, and project control. Estimators could perform a material takeoff, assign a crew, and estimate output per day. They could then use the Job Camera photographs to see how long the project actually took. In addition, because Job Camera photographs provide the date of the photograph, the information could be used to complete Construction Daily Reports and update schedules.

The authors also see potential for two additional studies. First, because all of the students answered question 3 the same as question 5, this implies that students interpreted their ability to identify activities the same as their ability to sequence activities. The lead author initially thought that identification and sequencing were separate and that a respondent might be able to sequence a list of activities provided, yet not be able to identify the necessary items from the plans and specifications. This is an area that was not specifically addressed in this study, but could warrant a follow-up study. Second, other researchers could consider incorporating the project's plans and specifications alongside the Job Camera technology to assist the student in being able to identify activities.

Dr. Richard D. Bruce is an Assistant Professor of Construction Management at Missouri State University in Springfield, and is a Member-at-large of Epsilon Pi Tau.

Dr. Chuck W. Berryman is an Associate Professor and Coordinator of the Construction Management Program at the University of Omaha in Lincoln, Nebraska.

Dr. David W. McCandless is an Assistant Professor and Coordinator of the Construction Management Program at the University of Central Missouri in Warrensburg.

Dr. Shawn D. Strong is an Assistant Professor and Head of the Department of Technology and Construction Management at Missouri State University in Springfield, and is a Member-at-large of Epsilon Pi Tau.

References

American Council for Construction Education (ACCE). *Document 103: Standards and criteria for accreditation of postsecondary construction education degree programs.* Retrieved January 30, 2009 from the World Wide Web: http://www.acce-hq.org/documents/ DOCUMENT103080906_005.pdf

Bruffee, K. A. (1999). *Collaborative learning: Higher education, interdependence, and the authority of knowledge.* (2nd ed.). Baltimore: John Hopkins Press.

Glavinich, T. E. (2004). *Construction planning and scheduling.* (2nd ed.). Alexandria: Associated General Contractors of America.

Hinze, J. W. (2008). *Construction planning and scheduling* (3rd ed.). Hoboken: Pearson

Mattila, K. G., Pocock, J. B., & Sauermann, P. C. (2006). Methods to assist in teaching planning and scheduling. *International Proceedings of the 42nd Annual Conference of the Associated Schools of Construction.* The University of Southern Mississippi: ASC.

McManus, B., Songpiriyakij, T., & Ryan, R.C. (2006). Using an as-built scheduling exercise.

International Proceedings of the 42nd Annual Conference of the Associated Schools of Construction. The University of Southern Mississippi: ASC.

Merriam, S. B. (2001). *The new update on adult learning theory*. San Francisco: Jossey-Bass.

Minium, E. W., Clarke, R. C., & Coladarci, T. (1999). *Elements of statistical reasoning* (2nd ed.). Hoboken: Wiley.

Mubarak, S. A. (2005). *Construction project scheduling and control.* New Jersey: Pearson.

National Public Broadcasting Archives (NPBA). *Archives of Association for Educational Communications and Technology (AECT)*. Retrieved October 14, 2005 from the World Wide Web: http://www.lib.umd.edu/NPBA/papers/aect.html#prov

North Dakota Department of Transportation (NDDOT). Four Bears Bridge (Project Website). Retrieved October 12, 2005 from the World Wide Web: http://www.fourbearsbridge.com

Nunnally, J. 1978. *Psychometric theory*. New York: McGraw-Hill.

Oxblue Corporation. (Company Website). Retrieved October 18, 2005 from the World Wide Web: http://www.oxblue.com

Patrick, C. (2004). *Construction project planning and scheduling.* New Jersey: Pearson.

Pinsky, L. E. & Wipf, J. E. (2001). A picture is worth a thousand words: Practical use of videotape in teaching. *Innovations in Education and Clinical Practice,* 805-810.

Schein, E. H. (1996). Culture: The missing concept in organization studies. *Administrative Science Quarterly*, 41, 229-240.

Russell, G. (2000). Print-based and visual discourse in schools: Implications for pedagogy. Discourse: Studies in the Cultural Politics of Education, 21(2), 205-217.

Scribner, J. P., & Donaldson, J. F. (2001). The dynamics of group learning in a cohort: From non-learning to transformative learning. *Educational Administration Quarterly, 37*(5), 605-636.

Senge, P. M. (1990). The leader's new work: Building learning organizations. *Sloan Management Review,* 32(1), 7-23.

Stevens, J. D. (1990). *Techniques for construction network scheduling.* New York: McGraw- Hill.

Trochim, W. & Donnelly, J. P. (2007). The research methods database. Retrieved January 30, 2009 from the World Wide Web: http://www.socialresearchmethods.net/kb/design.php

Weimer, M. (2002). Learner-centered teaching: Five key changes to practice. San Francisco: Jossey-Bass.

Appendix A Term Project Assignments (included in syllabus)

Component	Specifics	Due Date	Points
#1 Define the Activities	Review the Job Camera photographs to arrive at 50 activities.	8/31	5
#2 Put the Activities in Order	Create an ACT/IPA chart listing the activities and their immediate predecessors based on given logic.	9/7	10
#3 Diagram the Activities	Draw an activity on arrow (AOA) diagram in pencil on 17” x 22” graph paper following proper conventions. The diagram shall have a title block and shall be folded into fourths so that it will be 8.5” x 11”.	9/21	15
#4 Determine Activity Durations	Update the ACT/IPA chart with a column for durations.	9/28	15
#5 Calculate the Schedule Using the AOA Method	Create a new AOA diagram with corrections. Complete a forward and backward pass and note total float and free float. Again, use 17” x 22” paper folded into fourths.	10/5	15
#6 Repeat Assignments 3 and 5 Using the AON Method	Draw the schedule using the precedence diagramming method. Complete a forward and backward pass and note total float and free float. Use 17” x 22” graph paper folded into fourths.	11/2	15
#7 Computer Applications	Print out the schedule in MS Project, Sure Trak, and P3 (Gantt). Provide a one page cover sheet comparing the three software packages.	12/7	20
#8 Project Folder	Organize the preceding items in a folder and insert it in the course notebook. Include a table of contents for the project folder.	12/14	5
		Total	100

Appendix B First Two Term Project Assignments for Four Bears Bridge

	ACT	IPA
1	Receive notice to proceed	-
2	Order Cranes	Receive notice to proceed (1)
3	Order Steel	Receive notice to proceed (1)
4	Order Barges	Receive notice to proceed (1)
5	Clear Embankment	Receive notice to proceed (1)
6	Cut access roads	Clear Embankment (5)
7	Drive shore sheet piles	Clear Embankment (5)
8	Deliver Cranes	Order Cranes (2)
9	Deliver Steel	Order Steel (3)
10	Deliver Barges	Order Barges (4)
11	Survey casting building	Clear Embankment (5)
12	Layout casting building	Survey casting building (11)
13	F/R/P Footings/SOG	Layout casting building (12)
14	Erect casting building	F/R/P Footings/SOG (13)

15	Layout piles	Receive notice to proceed (1)
16	Drive 2 piles	Layout piles (15), Deliver Crane (8), Deliver Steel (9)
17	Set/Raise frame	Drive 2 piles (16)
18	F/R/P Cofferdam Base	Deliver Barges (10)
19	Transport Cofferdam Base	F/R/P Cofferdam Base (18)
20	Set Cofferdam Base	Set/Raise frame (17), Transport Cofferdam Base (19)
21	Drive 13 Diagonal Piles	Set Cofferdam Base (20)
22	R/P Pier Base	Drive 13 Diagonal Piles (21)
23	Disassemble frame	R/P Pier Base (22)
24	R/F/P Pier Column	Disassemble frame (23)

Appendix C Job Camera Effectiveness Survey

The following short survey is an attempt to find out if viewing Job Camera photographs had an impact on your ability to identify and sequence activities. Please circle the best answer and provide any comments at the bottom of the sheet.

1. Which of the following semesters were you enrolled in CMgt 3355 Construction Scheduling?
   A. Fall 2004 Term Project: Madison, WI Clinic (from steel on, pre-cast, EPDM roof, brick)
   B. Spring 2005 Term Project: East Texas Clinic (ground up, steel, EIFS)
   C. Fall 2005 Term Project: Four Bears Bridge (cofferdams, piers, bridge deck)
2. Which of the following best describes your level of general construction experience before taking CMgt 3355 Construction Scheduling? 1 summer = 3 months, so 4 summers = 1 year.
   A. No experience
   B. 1 week to 3 months
   C. 3 months to 1 year
   D. more than 1 year
3. Which of the following best describes your ability to identify activities required to complete this type of project before viewing the Job Camera photographs?
   A. I would not have been able to identify any of the required activities.
   B. I would have been able to identify 1-50% of the required activities.
   C. I would have been able to identify 51-75% of the required activities.
   D. I would have been able to identify 76% or more of the required activities.
4. Which of the following best describes your ability to identify activities required to complete this type of project after viewing the Job Camera photographs?
   A. I would not have been able to identify any of the required activities.
   B. I would have been able to identify 1-50% of the required activities.
   C. I would have been able to identify 51-75% of the required activities.
   D. I would have been able to identify 76% or more of the required activities.
5. Which of the following best describes your ability to put the activities in correct sequence for this type of project before viewing the Job Camera photographs?
   A. I would not have been able to sequence any of the required activities.
   B. I would have been able to sequence 1-50% of the required activities.
   C. I would have been able to sequence 51-75% of the required activities.
   D. I would have been able to sequence 76% or more of the required activities.
6. Which of the following best describes your ability to put the activities in correct sequence for this type of project after viewing the Job Camera photographs?
   A. I would not have been able to sequence any of the required activities.
   B. I would have been able to sequence 1-50% of the required activities.
   C. I would have been able to sequence 51-75% of the required activities.
   D. I would have been able to sequence 76% or more of the required activities.

Student Comments: ____

____

Perceptions of Students' Learning Critical Thinking through Debate in a Technology Classroom: A Case Study

Sophia Scott

Abstract

Critical thinking is often a desired competency for graduates of a technology program. Organizational members have uttered concern about students' inability to think critically. Although traditional pedagogical techniques, such as lectures and examinations, center on knowledge acquisition, debates in the technology classroom can effectively facilitate critical thinking. The purpose of this study was to gather via questionnaires the perceptions of technology students on the debate process used in the classroom to increase critical thinking. Overall, the students believed that the debate process was a useful learning activity. The results of the questionnaire revealed that students believed that the debates helped them understand the topic better, learn new knowledge, and gain an understanding of the debate process. In addition, students thought that the debates increased their critical thinking skills.

Introduction

Employers value employees who can solve complex problems, communicate effectively, and think critically (Gokhale, 1995). A function of higher education is to teach students to think. University accreditation boards, for example, the National Association of Industrial Technology (NAIT), the Accreditation Board of Engineering and Technology (ABET) and the International Technology Education Association (ITEA) recognize competencies such as problem solving, communication, and teamwork (including critical thinking) in their accreditation criteria (NAIT, 2007; ABET, 2007; & ITEA, 2007). Despite the emphasis on these competencies, businessmen and businesswomen have expressed concern with students' inability to integrate competencies, for example, teamwork, communication, and oral presentation skills with critical thinking (Roy & Macchiette, 2005). Bissell and Lemons (2006) ascertained that faculty who teach at universities in a technology or engineering curriculum consider critical thinking a primary objective. It is a sad truth that the "average" college student does not think critically, and not all courses include critical thinking.

Technology professors in higher education tend to focus on teaching discipline-specific content knowledge, but often they struggle with the time and resources needed to design effective strategies in order to teach critical thinking (Goodwin, 2003). Although traditional pedagogical techniques such as lectures and examinations center on knowledge acquisition, debates in the classroom can effectively facilitate critical thinking (Roy & Macchiette, 2005). Therefore, debate as a teaching tool, has a place in pedagogical methods because it allows students to enhance critical thinking through investigating arguments, engaging in research, gathering information, performing analysis, assessing arguments, questioning assumptions, and demonstrating interpersonal skills.

Purpose

Initially, the researcher used debate in a Science, Technology, and Society course as a tool to introduce an experiential learning opportunity. The main objective of the course was to use a selection of modern topics in science and technology to increase communication and critical-thinking skills. Debate was a natural fit for the course because the topics were tied to current events, and students were allowed to critically analyze a controversial topic while practicing other competencies like writing, presenting information and higher level thinking. Because the debate was a new experience for the students, it was essential to learn their perceptions of the debate process by asking the following questions:

1. What was their perception of the debate process in a technology classroom?

2. Did they believe the debates increased their critical-thinking ability?

This study highlights the procedure the researchers used in implementing debates in the technology classroom. In addition, the perceptions of technology students will be discussed.

Review of Literature

How can professors transform the student from a passive learner to an active learner? The typical college classroom used to be dominated by the passive learning strategy, *lecture*. In university classrooms, professors now implement active learning strategies, such as discussions, role playing, case studies, and debate. Vo and Morris (2006) used debate to supplement the traditional lecture by engaging the learner. Debate also allows professors to create an environment that helps students move away from just receiving knowledge into an atmosphere of active participation. Additionally, debating contemporary issues in the technology classroom can be an invaluable tool for encouraging critical thinking (Dickson, 2004).

Defining Critical Thinking

Halpern (1996) characterized critical thinking as the use of cognitive skills or strategies to increase the probability of a desirable outcome. Critical thinking also involves evaluating reasoning and factors considered in making decisions. According to Paul and Elder, (2006) a well-cultivated critical thinker solves a complex problem by raising vital questions, gathering relevant information, determining findings, and communicating effectively. Maiorana (1992) noted that the purpose of critical thinking is to use questioning techniques to achieve understanding, evaluate view-points, and solve problems. The debate process can also help student's master content. This researcher believes that using debate as a teaching tool helps students develop specific skills (i.e., analyzing, synthesizing and evaluating supported arguments). In addition, the debate process incorporates critical thinking and a plethora of other skills including, listening, researching, problem solving, reasoning, questioning, and communicating.

Evaluating Critical Thinking

Scientific thinkers seek to quantify, explain, and predict relationships. It is reasonable to conclude that science and technology courses are a good place to learn critical thinking by using the scientific thinking (Schafersman, 1991). The scientific method involves asking questions, researching information, developing questions, testing, analyzing, and communicating results. All of these involve different levels of critical thinking (Paul & Elder, 2006). Brookfield (1997) believes that critical thinking can be analyzed in terms of process and purpose. The very process of debate allows students to recognize the assumptions that underline their thoughts and actions. There are many ways that critical thinking has been assessed in the classroom, including using pre- and posttests, case studies, storytelling, questioning, role playing, and debates.

Another way to evaluate critical thinking is through classification. Bissell and Lemons (2006) consider Bloom's taxonomy the way to categorize critical thinking in the classroom. Bloom, Englehart, Furst, Hill, and Krathwohl (1956) developed a classification for learning. This classification can be used to evaluate critical thinking using six levels of cognitive thinking. The debate exercise modules in this study have been developed using Bloom's Taxonomy (see Table1).

Students progress through the levels of the taxonomy from lowest to highest. Although critical thinking exist at every level, higher order thinking occurs at the synthesis and evaluation level.

Use of Debate in the Technology Classroom

Debates in science and technology classes can help the students explore topics that affect society. Proulx (2004) used debate in the classroom for analyzing, testing, and evaluating arguments. Vo & Morris (2006) also found that debate increased the benefits of the traditional lecture by engaging the learner in the material. Additionally, Osborne (2005) established that debate in the classroom is effective in helping

Table 1 Bloom's Taxonomy

Category	Description
Knowledge	Ability to recall previously learned material.
Comprehension	Ability to grasp meaning, explain, restate ideas.
Application	Ability to use learned material in new situations.
Analysis	Ability to separate material into component parts and show relationships between parts.
Synthesis	Ability to put together the separate ideas to form new whole, establish relationships.
Evaluation	Ability to judge the worth of material against stated criteria.

students learn a discipline and demonstrate the ability to read and write critically. The ability to write effective arguments influences success of students in preparation for their future careers. Dickson (2004) declared that the debate process assessed the student's ability to write effectively, work in teams, and analyze arguments, all of which can improve the ability to think critically. Critical thinking that includes debate also allows for collaboration. Collaborative teams can achieve higher levels of thinking through the use of persuasive evidence. This collaboration allows individuals to retain information longer and the opportunity to engage in discussion and shared learning (Gokhale, 1995). Lewis and Wakefield (1983) emphasized individual learning, as well as, team formal and extemporaneous speaking in the debate process.

Walker and Warhust (2000) claimed that debates in the classroom have been effective in increasing critical thinking by letting students to connect as they learn subject knowledge. In their classes, they found that 82% of students thought that they understood the subject matter, and 85% believed that they learned something valuable. In addition, debates boosted the analytical problem solving, communication, presentation and the ability to form teams. Moeller (1985) found that while many students were apprehensive about the debates, the process proved to be valuable and helped them in increasing their critical-thinking skills. Goodwin (2003) used debate to help students master the content in the class and asked students their perception of the debate process in the classroom. Several students commented on the unfamiliarity of the debate process and that the debate was uncomfortable. A majority of the students responded that the debate process was useful in gaining disciplinary knowledge and this process helped them with analyzing and presenting arguments. Students also replied that classroom debates helped them to recognize and deal with various points of view and improved their critical thinking.

The Debate Process

Traditional debates take many formats. The most common classroom debate is traditional debate (Ericson, Murphy & Zeuschner, 2003). The debate process in this study started with the central resolution. Such a resolution is a declarative statement that the team will either support or oppose. The affirmative team supports the resolution, and the negative team opposes it. The students built a case for the resolution (the case brief) in which they try to prove or disprove the resolution through evidence. In utilizing debate in the classroom, the professor should take an active role in coordinating the planning it (Roy & Macchiette, 2005). He or she should distinguish the debate brief from other forms of written reports and stress the persuasion needed in the debate speeches. The debate process involved planning and considerable time spent preparing the students for the formal debates. Students need to understand the debate process and terminology. There are several debate guides to help explain the debate process (Ericson, Murphy, & Zeuschner, 2003). Additionally, Roy and Macchiette (2005) emphasized that the professor should seek responses from the students and that evaluation can be conducted in a variety of ways.

Methods

This study investigated students' perceptions of the debate process used in a technology classroom to increase critical thinking.

Subjects

The study included 111 students enrolled in a Science, Technology, and Society course in the fall and spring of 2005-2006. The course was taught by two professors. The students performed one debate during the semester in which they participated in the course and they were asked to fill out a questionnaire authored by the researcher.

Procedure

The procedure for the research included the following steps:

1. *Preparing students for the debates.* Students were divided into teams of four and given a resolution (see Table 2). The students were introduced to the debate process and were given an assignment sheet that outlined the debate process and instructions on preparing the case brief. The Appendix includes an example of a case brief. Students had time in and out of the classroom to prepare for the debates.

2. *Performance of the debates.* The students performed the debates. The students were then assessed on the quality of the debates.

Table 2 Debate Resolutions

Debate Resolutions	
One	Resolved: the United States should allow new embryonic stem cell research
Two	Resolved: the United States should allow human cloning for research purposes
Three	Resolved: the United States should allow monies to be exchanged for human organs for transplant patients
Four	Resolved: the United States should regulate content on the Internet for minors
Five	Resolved: the United States should adopt a flat income tax

3. *Students filled out the questionnaire.* Following all of the debates, the students were asked to sign a consent form and asked to fill out the questionnaire.

Findings

Question 1: What was the student's perception of the debate process in a technology classroom?

The student questionnaire consisted of nine questions using a four-point Likert scale (1 =strongly disagree, 4= strongly agree). There was one open-ended question on the students' opinion of the debate process. Table 3 provides the question and the mean response from the students.

Table 3 Mean Score of Student Responses

Question	*M*
I learned new knowledge about the topic I debated	3.53
I gained an understanding of the topic area of my debate	3.42
I felt comfortable explaining my position in the debate	2.95
Writing the case brief helped me to break the information into manageable parts	3.11
The debates helped me know the difference between fact and opinion	2.94
I was able to defend my position in the debate	2.99
I was able to gain additional knowledge on subjects that I was not aware of by listening to the debates	3.29
The debate process helped me increase my critical- thinking skills	3.16
I prefer to prepare a debate rather than to take a test	3.04
Total	3.16

The results of the questionnaire revealed that students believed that the debates helped them to learn new knowledge (3.53), to gain an understanding of the topic (3.42) and to gain additional knowledge on the subject (3.29). Students replied that they would rather prepare for a debate than take a test (3.16).

Question 2: Did students believe the debates increased their critical-thinking ability?

Students were asked if they felt that the debates increased their critical thinking. Students believed that debates did increase their critical thinking skills (3.16). It was important to the researcher to get the student perception of the debate process by allowing an open response question. Students commented that they enjoyed the debate process and that it was a good experience. Many class members thought the debates were challenging. Some of the students did not like speaking in front of the class or trying to defend their cases. Other students commented on the debate process as a good tool for working in teams and thinking critically.

Discussion and Implications

Debate in the technology classroom can yield great learning for the student. Debate as a teaching strategy allowed active learning on the student's part; it also allowed the students to demonstrate different levels of critical thinking. Students learned through the process of preparing the debate, performing the debate, listening to debates, and discussing the debate. Favorable outcomes of debates observed by the researcher included collaborative learning and higher order thinking. Because debate is being used in the classroom in a pedagogical manner, a structured debate with assessment was used. The experience with debates in the technology classroom was largely positive. Weaknesses were observed in the student's writing. Additionally, students lacked research and reasoning skills. In the debate speeches, students also often lacked confidence and questioning skills.

Debate can be challenging in the technology classroom. Students may reject a different teaching strategy used to learn critical thinking. Most students were highly satisfied with the debate process and felt that the debates increased their critical-thinking skills. However, some students did not enjoy the debate process. Despite this minor issue, a science and technology course is an excellent environment to increase critical thinking through the use of debates.

Summary and Conclusions

Integrating critical thinking with other needed competencies like teamwork and communication is a worthwhile activity for the technology classroom. The debate process can be useful in gaining disciplinary knowledge and helping students with analyzing and presenting arguments. Furthermore, debate as a teaching tool, has a place in pedagogical methods because it allows students to enhance critical thinking through investigating arguments, engaging in research, gathering information, performing analysis, assessing arguments, questioning assumptions, and demonstrating interpersonal skills. Debate is a great supplement to the traditional lecture class because it engages the learner in the material. Debate also allows professors to create an environment that helps students move away from just receiving knowledge into an environment of active participation. Additionally, debating contemporary issues in the technology classroom can be an invaluable tool for encouraging critical thinking.

The results of this study only reflect experiences in this course and are not meant to provide evidence of student learning on critical thinking. According to this research, there is merit in debate as a teaching strategy. More research should be conducted in the area using debate in the technology classroom to increase critical thinking. In conclusion, preparing, grading, and evaluating the debate process can be time consuming, but may be worth pursuing in the technology classroom.

Dr. Sophia Scott is an Assistant Professor in the Department of Industrial and Engineering Technology at Southeast Missouri State University, Cape Girardeau, and is a Member - at -large of Epsilon Pi Tau.

References

ABET (2007). The Engineering Accreditation Commission of the Accreditation Board of Engineering and Technology. Accreditation handbook online. Available at: http://www.abet.org.

Bissell, A. N. & Lemons, P. P. (2006). A new method for assessing critical thinking in the classroom. *BioScience.* 56(1). 66-72.

Bloom, B. S., Englehart, M.D., Furst. E. J., Hill W.H. and Krathwohl, D. R. (1956). Taxonomy of educational objectives: The classification of educational goals, handbook 1 cognitive domain. New York: McKay.

Brookfield, S.D. (1997). Assessing critical thinking. New Directions For Adults and Continuing Education. No. 75, Fall. Jossey-Bass Publishers. Pp. 17-29.

Dickson (2004). Developing "Real-world intelligence": Teaching argumentative writing through debate. English Journal. 94(1). 34-40.

Ericson, Murphy & Zeuschner. (2003). The debater's guide. (3rd ed). Carbondale: Southern Illinois University Press.

Gokhale, A, A (1995). Collaborate learning enhances critical thinking. *Journal of Technology Education.* 7(1).

Goodwin, J. (2003). Students' perspectives on debate exercises in content area classes. *Communication Education.* 52(2). 157-163.

Halpern, D. F. (1996) Thought and Knowledge: An Introduction to Critical Thinking. Mahwah, NJ: L. Erbaum Associates.

ITEA (2007). International Technology Education Association. Available: http://www.iteaconnect.org.

Lewis, L. M & Wakefield J. A. (1983). Teaching psychology through an instructor-debate format. *Teaching of Psychology.* 10(2). 115-119.

NAIT. (2007) Industrial Technology Accreditation Handbook On-line. Michigan: The National Association of Industrial Technology (NAIT). http://www.nait.org.

Maiorana, V. P. (1992). Critical Thinking Across the Curriculum: Building the Analytical Classroom. Bloomington, IN: Eric Clearinghouse.

Moeller, T. G. (1985). Methods and techniques: Using classroom debates in teaching developmental psychology. *Teaching of Psychology 12*(4). 207-209.

Osborne, A. (2005). Debate and student development in the history classroom. *New Directions for Teaching & Learning*. 103. 39-50.

Paul, R. & Elder, L (2006). The Miniature Guide to Critical Thinking Concepts and Tools. Dillion Beach CA: The Foundation for Critical Thinking.

Proulx, G. (2004). Integrating scientific method and critical thinking in classroom debates on environmental issues. *The American Biology Teacher. 66*(1). 26-33.

Roy, A., & Macchiette, B. (2005). Debating the issues: A tool for augmenting critical thinking skills of marketing students. *Journal of Marketing Education.* 27(3). 264-276.

Schafersman, S. D. (1991) An introduction to critical thinking. Accessed Mar 26, 2007. Available online at http://www.freeinquiry.com/critical-thinking.html

Vo, H. X. & Morris, R. L. (2006) Debate as a tool in teaching economics: Rationale, technique, and some evidence. *Journal of Education for Business.* 315-320.

Walker, M. & Warhurst, C. (2000). "In most classes you sit around very quietly at a table and get lectured at…": Debates, assessment and student learning. Teaching in Higher Education 5(1). 33-49.

Appendix Case Brief Example

Introduction (catch the audience attention)

Resolution:

Terms to define

Contention 1:

Evidence

Reasoning

Contention 2:

Evidence

Reasoning

Inherency (the need or lack of need for a plan)

Plan:

How plan will help with the resolution:

Conclusion:

From Jefferson to Metallica to your Campus: Copyright Issues in Student Peer-to-Peer File Sharing

Lisa McHugh Cesarini and Paul Cesarini

If nature has made any one thing less susceptible than all others of exclusive property, it is the action of the thinking power called an idea, which an individual may exclusively possess as long as he keeps it to himself; but the moment it is divulged, it forces itself into the possession of everyone, and the receiver cannot dispossess himself of it. Its peculiar character, too, is that no one possesses the less, because every other possesses the whole of it. He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine receives light without darkening me.

--Thomas Jefferson, 1813

When Lars Ulrich, drummer for the rock group Metallica, testified before Congress about his group's lawsuit against Napster in 2000, many people who followed copyright issues in the music industry were not surprised (Ulrich, 2000). Ever since downloading audio files became as easy as clicking a few buttons on a personal computer, charges of copyright infringement have been alleged and played out in the courts. The real surprise came when Indiana University, Yale University, and the University of Southern California also were named in the suit for allowing students to use their university computer networks to illegally downloading music files. The idea that colleges and universities could be held liable for their students' actions in this way was unsettling at the time, and to this day, questions linger about the role higher education should play in this arena from both legal and ethical perspectives.

Recent court decisions have not provided any greater insight and the legislative actions seem as informed by lobbyists as best practices on how to actually prevent and deter illegal activity while allowing legitimate and potentially innovative activity. Kaplin and Lee (2007) clearly outline the need for students and faculty in the higher education community to be informed and proactive, both individually and collectively, in these matters:

Until recently, copyright law merited little attention within the academy, but the rapid integration of digital technologies into American life has increased the relevance of this body of law and made necessary a broader understanding of its basis, how it works, and the role it plays in the controversies that are shaping how faculty and students will use technology and information in the future. (p. 616)

Although the relevance of this topic within higher education is clear, interpretations of legislation as well as court decisions have not provided much clarity on the balance between fair use and copyright infringement of digital media, regardless of whether the digital media in question was audio, video, or text. In addition, there has been much disagreement within the higher education community as well as on individual campuses about the role institutions should play in pursuit of copyright infringers, both intentional and unintentional, some of whom may be the institution's own students, faculty, and staff. In a 2000 press release written in response to the Napster lawsuit, officials at Indiana University claimed that " . . . technology has leaped well ahead of clear legal issues" (Indiana University, 2000) and as such, Napster would be banned from their campus network until the issue could be further investigated. As a result, both Indiana University and Yale were dropped from the suit once that it was announced that Napster would be banned on those campuses as well (Carlson, 2000).

Other campuses effectively banned Napster by means such as packet shaping (sometimes referred to as "traffic shaping" or "traffic engineering"). Regardless of whether a student attempts to share vacations photos with a friend or one of Metallica's latest tracks, the information transmitted over the network is broken down into small bundles, or "packets," identified by the type of data. So, by way of certain types of network management software, these packets essentially can be identified by their genre: Email traffic, course management traffic, general web surfing traffic, and peer-to-peer (P2P) file sharing traffic. By deploying a program such as Pack Shaper or Packeteer, an institution can manage network traffic by throttling down the available bandwidth for certain types of packets, while throttling up the bandwidth for other types (SearchNetworking, n.d.). Packet shaping has largely become the default method for dealing with P2P file sharing in higher education, but in 2000 it was probably considered a fairly new and obscure technology by end-users of such networks, and students largely greeted it with contempt. At Bowling Green State University, for example, photocopied flyers proclaiming "Save Napster!" were plastered throughout the campus, with particular emphasis given to the building that housed the Information Technology Services department.

At the time, Napster was the only P2P file sharing application, so banning that one application (either via packet shaping or by other means) was a relatively simple solution. As the name implies P2P file sharing allows individual users to share files without a centralized server. The Napster network added another dimension: Simply put, users share files through an intermediary where the network served as a centralized database (McCormick, 2006; Tech Encyclopedia, 2008). Since Napster in 2001, numerous applications have existed and used various protocols for sharing and distributing files, making it more difficult to restrict on a campus network. Eight years later, many campuses still struggle with the very same issues.

Copyright and Intellectual Property over the Years

While ultimately the issue of intellectual property involves legal issues of copyright, trademark, and patent laws, this discussion will focus on copyright law and the widening gap between it and advances in information and communication technologies. An important component of copyright law affecting higher education is that of fair use, which Kaplin and Lee (2008) describe as "one of the most misunderstood copyright issues" (p. 617).

According to the Copyright Act, four considerations are used to determine fair use: (a) the purpose of the use: whether it is for commercial or educational use, (b) the nature of the copyrighted work, (c) how much of the work is used in relation to the entirety of the copyrighted work, and (d) the impact of the use on the potential market or value of the work (Kaplin & Lee, 2007). Because the fair use doctrine applies to both published and unpublished works, in hard copy, on the Internet, or when used as part of an online course (Kaplin & Lee, 2007), this is an important factor when considering the legality of using or downloading digital files regardless of whether the user is on a P2P network. Response to two legal suits in 1987 and 1989 severely restricted the definition of fair use in unpublished materials to the point of essentially not allowing any use of the work. Congress passed the Copy Amendments Act of 1992 (Kaplin & Lee, 2007), which returned to the original fair use standards.

Hilton (2006) asserted that the most disruptive force facing higher education relating to information technology is that "we live in a culture and society that increasingly views the world of ideas as pure property" (p. 64). He claims we should be very weary of this perspective and cites John Perry Barlow's analogy of someone stealing your car versus someone stealing your idea. If your car is stolen, you cannot use it but if someone steals your ideas, they are still available for your use. The notion of "ideas as property" is not a recent phenomenon in American society. In 1939, noted author and futurist Robert Heinlein wrote in his short story entitled *Life Line* about the confusion regarding property rights:

> There has grown up in the minds of certain groups in this country the notion that because a man or a corporation has made a profit out of the public for a number of years, the government and the courts are charged with the duty of guaranteeing such profit in the future, even in the face of changing circumstances and contrary public interest. This strange doctrine is not supported by statute nor common law. Neither individuals nor corporations have any right to come into court and ask that the clock of history be stopped, or turned back, for their private benefit. (p. 21)

The notion of intellectual property and copyright issues has been a part of our legal history for as long as the United States has been a country. In the United States Constitution (1787), Congress is charged with the Copyright Act "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries" (art. I, § 8, cl. 8). According to Kaplin and Lee (2007), the goal of the Copyright Act "simply stated, is to increase knowledge" (p. 616). At first glance, this view may seem remarkably consistent with the basic tenets of higher education, but in the instance of copyright issues it often seems at cross purposes.

The phrase in the Constitution "for limited times" has been the source of much debate as it is applied to the issue of intellectual property rights and fair use of digital media. Some researchers believe that the timeframe for ownership should not be limited. In her 1998 Congressional testimony, Rep. Mary Bono indicated that she agreed with her late husband who wanted the "term of copyright protection to last forever. I am informed by staff that such a change would violate the Constitution" (Bono, 1998, para. 3). In her remarks, Bono also quoted former actor and Recording Industry Association of America (RIAA) President Jack Valenti who proposed that the term for copyright protection should be "forever less one day" (Valenti in Bono, 1998, para. 3).

While the RIAA and those it represents may feel entitled to the profits from their work and the ability to control how their work is used, many feel the approaches used by the RIAA in pursuit of illegal downloading are questionable and perhaps even illegal. McCormick (2006) describes the scenario as "college and university students downloading digital files are perceived as pirates and thieves by the content industry, while the students perceive the recording industry as greedy philistines, and thus ignore intellectual property rights" (p. 682).

In 2003, the RIAA began suing direct infringers of copyrighted audio files, creating even more ill will as well as involvement of campuses who were requested to turn over the names of any students accused of violations. Their approach was to identify users internet protocol (IP) addresses and send those users to their institution as the ISPs. The institution then forwards the pre-settlement letter to the student/user allowing the student to pay thousands of dollars to avoid any further legal action (Cornell, 2007). If a student does not settle, then the RIAA files suit as part of a "John Doe" case, which results in a subpoena for the institution to reveal the name of the student (Cornell, 2007). The RIAA's case was not helped when the following wording was posted on its website and used in many of its media messages: "No black flags with skull and crossbones, no cutlasses, cannons or daggers identify today's pirates. You can't see them coming; there's no warning shot across your bow. …Today's pirates operate not on the high sea but on the Internet..." (RIAA, 2003, para. 1). This quote created so much attention that it became a sort of rally cry for many users of P2P file sharing applications as well as those students, faculty, and fair use activists who feel the enforcement of copyright law has been taken to an extreme.

Hilton (2006) believes this type of approach is excessive and remarks that "as originally enacted, copyright was designed to balance the limited property rights of the author/creator with the long-term rights of the public. The problem is that over the years, copyright has changed in ways that have consistently increased the protection granted to authors without providing increased benefit to the public" (p. 66). It is easy to see how such comments by the RIAA, Bono, Valenti, and others, such as the Motion Picture Association of American (MPAA), fuel this ongoing feud which, combined with the relative ease and anonymity of downloading media files, has culminated in the current situation.

Legal Precedence: Clear as Mud

The landmark copyright case related to digital media was the Supreme Court ruling in *Sony Corp. of America v. Universal City Studios, Inc.,* 464 U.S. 417 (1984). In this case, Universal City Studios brought suit against Sony, then a manufacturer of Betamax-based video cassette recorders (VCRs) for copyright infringement because the VCR owners were taping movies and shows off of their televisions. According to Kaplin and Lee (2007), the Supreme Court ruled that Sony was not liable for the infringement of its customers because "the recorders had substantial non-infringing uses, namely timeshifting of television programming" (p. 620). Further, the Court ruled that taping a television show and viewing it later was considered fair use. McCormick (2006) suggested that the United States Supreme Court should revisit its decision in Sony since the precedent set by this over broad ruling in the 1984 case is outdated, yet continues to be applied.

Fast forward seventeen years to the next significant case of copyright involving the use of media files between with A&M Records v. Napster, 239 F.3d 2004 (9th Cir. 2001). McCormick (2006) shared the district court's view of this case as: "The matter before the court concerns the boundary between sharing and theft, personal use and the unauthorized worldwide distribution of copyrighted music and sound recordings" (p. 689). In this case, A&M

Records alleged that Napster was knowingly allowing (and even encouraging) customers to illegally download audio files. In 2001, the 9th Circuit court, based on *Sony*, rejected Napster's defense, which focused on claims of fair use (Kaplin & Lee, 2007, p. 620). The primary difference between Sony and Napster was that there was no further contact once Sony sold the VCR to a customer, but Napster did have contact with its subscribers and could bar them from using the service at any time. According to Hall (2006), "because the centralized indexing system allowed Napster to have actual knowledge of specific infringement and control over the infringement, the court found that . . . Napster was liable for contributory and vicarious infringement" (p. 390).

Shortly after *Napster*, another case was heard in the Seventh Circuit Court of Appeals. In *Aimster Copyright Litigation*, 334 F.3d 643, 645 (7th Cir. 2003), the court applied both *Sony* and *Napster* and found that even though *Aimster* was used for many noninfringing uses, the proportion of infringing uses to noninfringing uses was enough that "Aimster was required to proffer evidence that its network was actually used for . . . the stated noninfringing purposes to avoid contributory liability" (McCormick, 2006, p. 718).

The next significant case took place in 2004, when the 9th Circuit court heard *MGM Studios, Inc. v. Grokster, Ltd.,* 380 F.3d 1154 (9th Cir. 2004). Grokster was a network that became popular after the *Napster* ruling essentially ended operations. Grokster's network merely served as a distributor for its P2P software since the files shared by its users were not indexed in any centralized manner. In its ruling, the court did not find Grokster liable as a contributory infringer that "specifically contradicted the probable noninfringing use standard articulated by the Seventh Circuit in *Aimster*" (McCormick, 2006, p. 718).

The plaintiffs appealed to the Supreme Court in *MGM, Inc. v. Grokster (Grokster III)*, 125 S. Ct. 2764 (2005), and even requested that Congress consider legislation that would overturn *Sony*, which as mentioned above has been controversial because much of the legal and technological landscape in this country has changed during the ensuing twenty years. In 2005, the Supreme Court vacated the 9th Circuit's ruling and remanded it for further consideration based on four factors: (a) Grokster was promoting itself as a means to illegally download media files, (b) Grokster targeted former Napster users, (c) Grokster made no attempt to install filters to prevent illegal downloading, and (d) that most of the profits that would have gone to distributors who be from acts of copyright infringement (Kaplin & Lee, 2007). The Court's decision "did more to muddle the contributory infringement 'water' than to purify it" (McCormick, 2006, p. 719). Hall (2006) agrees that the Court's decision only compounded the confusion and went even further to say that the Supreme Court's decision ". . . added more fuel to the fire by . . . allowing the existing *Sony* test to apply where a product is used to infringe but there is no evidence of intentionally inducing the infringement" (p. 392).

Legislative Approaches

The Digital Millennium Copyright Act (DMCA) of 1998 was "the foundation of an effort by Congress to implement United States treaty obligations and to move the nation's copyright law into the digital age" (DMCA report, n.d.). One provision of the DMCA that applies to higher education is that of "anti-circumvention" clause which was an attempt to reinforce copyright holders' rights by not allowing them to "succumb to the unique threat posed by digital technologies" (McCormick, 2006, p. 716). Although this clause was written to protect the rights of copyright holders, some in higher education and those familiar with copyright issues view it as a "threat to civil liberties, the free exchange of information, and . . . academic freedom" (McCormick, 2006, p. 716).

Another relevant provision of the DMCA for institutions of higher education is that of safe harbor (DMCA, n.d.), which can limit the liability of Internet service providers (ISPs). Colleges and universities are considered ISPs and as such, this safe-harbor status can protect colleges and universities from monetary damages awarded if users of their computer network are found guilty of copyright infringement (McCormick, 2006, pp. 716-717). However, this protection is only extended when ISPs have and enforce a policy that informs all users of the legal issues surrounding electronic files and terminate from their network anyone who is a repeat offender (DMCA, n.d.).

The newest legislation proposed on this topic is the Higher Education Act

Reauthorization that would actually block federal financial aid for all students at an institution where a student repeatedly and illegally downloads media files. The American Council on Education (ACE) promptly reacted on behalf of 12 other higher education groups (ACE, 2008). While the groups were supportive of requiring campuses to inform their campus communities of their copyright infringement policies and possible consequences, they were not in favor of requiring institutions to "provide alternative music and movie services and implement technological measures to deter file sharing" (ACE, 2008, para. 3). The vagueness of this provision is problematic for two reasons. It does not specify what "provide" means; thus, it is unclear if an institution could simply make the free iTunes application available to students, or if institutions are required to purchase a legal streaming service license such as Yahoo! Music for their campus. In addition, requiring institutions to implement technological measures to block file sharing has not been cost effective or efficient.

In the letter written to the two ranking senators, ACE President David Ward assured the senators that "colleges and universities take illegal file sharing very seriously. Institutions deal with illegal file sharing through the education of their students, network management, and institutional policy enforcement" (ACE, 2008, para. 4). He challenged the 2005 MPAA statistics cited in the legislation that 44 percent of its domestic losses were due to illegal P2P file sharing by college students. According to Ward, the MPAA itself recently revealed after reexamination that the actual loss due to college students was only 15 percent and since only 20 percent of college students live on college campuses, only 3 percent of MPAA losses can be attributed to college students using campus networks. Given this small percentage and current technologies, it would be burdensome and ineffective to require campuses to purchase software that not only restricts network activity as well as students legally accessing digital media (Ward in ACE, 2008).

While institutions of higher education should not be complicit in the illegal downloading of files by their students, some academics and lawyers question if it is the role of higher education to be the enforcer of these laws and if, at public institutions, taxpayer dollars should be used to further support this seemingly outdated business model by purchasing detection and legal downloading software. According to Adrian Sannier, university technology officer at Arizona State University, in his testimony before the House Committee on Science and Technology in June, 2007, colleges and universities must be careful not to commit institutional funds in antipiracy software lest they "end up caught in an expensive 'arms race' between technology companies and enterprising file swappers" (Read, 2007, p. A34). Sannier's point is particularly relevant given that higher education information technology offices are already engaged in numerous other technological arms races, combating ever-increasing volumes of junk email, viruses, spyware, malware, and so forth. Opening up a new front in this arms race would likely prove costly on a variety of levels.

During that same hearing, Gregory A. Jackson, vice president and chief information officer at the University of Chicago, and Cheryl A. Elzy, dean of libraries at Illinois State University, testified that colleges and universities "would benefit at least as much from educational programs and improved legal-downloading services as they would from technological tools" (Read, p. A34). In response to these comments, Florida Representative Tom Feeney told the college administrators that he was "disappointed" that they had "minimized the potential of technological solutions" to piracy (Read, 2007, p. A34). He further warned that colleges and universities take "aggressive steps" to address illegal file sharing and insisted he would push institutions to use some type of antipiracy technology, "whether you like it or not" (Read, 2007, p. A34).

Delicate Balance of Student Rights and Institutional Liabilities

Although there are legitimate and legal means for P2P file sharing, the vast majority of press on this topic has been about the illegal file sharing, specifically by college students. Within the discussion on the legal rights of students to access digital media, there are essentially three main considerations: the definitions of downloading versus piracy, balancing content restriction with bandwidth issues, and the notion of creativity and innovation.

Often when the topic of downloading digital media is discussed, the first thought is that this is being done illegally. This illegal practice is commonly called piracy since it is viewed as essentially stealing content rather than paying a price to use or own it. However, downloading digital media has many legitimate, noninfringing uses both inside and outside of higher education. P2P file sharing is typical in small organizations where there is not a centralized server so that any user can use and share any file with another user within their network ("Tech Encyclopedia," 2008).

Other examples might include students in a band wanting to share their own music with known friends or unknown fans; students working on a group project in class sharing files with each other; students or faculty who have created original works – even commercial works – but want to allow "mash-ups" (creative reinterpretations) of it; or students who have filmed their own movies and have no other means for distribution. A recent example of noninfringing use of P2P includes fan-produced films, such as the user-created "new" episodes of the original *Star Trek* series, called "Star Trek: New Voyages" (recently renamed Star Trek: Phase II). Each of the current episodes available, all done via volunteers and strictly not-for-profit, rely on P2P as one of several distribution mechanisms since "bandwidth and storage are at a premium" and P2P makes more efficient use of both ("Star Trek: Phase II FAQ," 2008). Downloading and accessing these episodes represents a very clear, noninfringing use of P2P that could be used by students and faculty in assignments related to media studies, theater, film, popular culture, and others.

Another example would include computer enthusiasts wanting to share the newest Linux distribution or similar free/open source software (FOSS). Open source software, while in many cases has sponsorship from large technology companies such as IBM and Google, is still ultimately community driven with ISO disk images often being distributed by way of BitTorrent and similar P2P methods. Having this option available is not merely helpful; it is critical.

Dr. Louis Suarez-Potts serves as community manager for the OpenOffice.org project, an office productivity suite compatible with Microsoft Office and one of the largest open source projects in the world. Potts (2008) argues that P2P distribution is essential for this and numerous other open source efforts, "but for many, downloading [free and open source software] from fixed servers via fat pipes is impossible. These informational conduits are liable to be overused, and other strategies, such as the relatively slower but steady trickle of P2P, are required." He also stresses that the relationship between P2P and FOSS is not one purely associated with distribution of a final product. Rather, P2P also provides much of the critical connectivity needed to facilitate collaboration on such projects:

[P2P] depends on a floating and often invisible public whose nearly automatic sharing of material bypasses and renders nearly irrelevant the older model of static servers. And for free software, whose license not just allows but encourages the free distribution of the commodity and code, P2P not only is the natural vehicle but also grows the community upon which the software is built. (personal communication, September 3, 2008)

Hilton (2006) encourages colleges and universities to participate in the open source movement in support of the notion of free exchange of ideas. Open source software (such as Linux and OpenOffice.org) is primarily available through P2P filesharing since this shares the bandwidth overload and thus does not overburden any one network.

Creative Commons is another example of efforts to support copyright while supporting the public access to information. On the Creative Commons website, the claim is made that ends are cooperative and community minded, but the means are voluntary and libertarian (Creative Commons, n.d.), because it allows authors to choose a license that allows both commercial as well as non-profit use of work. Similar to open source software, many of the works licensed through Creative Commons are accessible through P2P networks. According to Morrill (2006), Creative Commons and P2P are ideally suited, and the piracy-related stigma surrounding P2P neglects the "hundreds of creative commons works that are in the [P2P] distribution channel" (para. 7). Examples of this would include sites like LegalTorrents, an "online digital media community" with the following goals:

We discover and distribute high quality open-license (Creative Commons) digital media and art, and provide support to Content Creators. We host creative content in its entirety, ensure fast, reliable downloads, and enable users to directly sponsor Content Creators and their work. We distribute content with the full permission of the rights holders and use the peer-2-peer file-sharing technology called BitTorrent. (2003, para. 1)

According to Hilton (2006), Creative Commons "provides a mechanism for sharpening the blunt instrument of copyright" (p. 70). P2P has become an important distribution means for this mechanism.

Hilton's (2006) assertion is admittedly more complex as it deals with the notion of creativity and dissemination of knowledge in society as well as the academy. This author states that "most people think that the primary purpose of copyright law is to protect an author's intellectual property or idea. In fact, the primary purpose of copyright law is to promote learning through the spread of ideas" (p. 66). Though not the typical response if one were asked about copyright, this definition is very much consistent with the academic values on which our colleges and universities were founded. As such it seems that higher education should strive all the more to balance the individual incentive to create new ideas with the sharing of and collective access to information. Without this balance, many future innovations could be stifled or at the very least delayed. According to Hall (2006), "P2P shaped the Internet as we know it today. If Internet service providers were initially aware of the possibility of being liable for online copyright infringement, the Internet might not be the wealth of ideas it is today" (p. 392).

Even though proposed legislation in Congress as well as the threat of lawsuits require institutions do more than merely hope students use P2P networks appropriately and legally, any institution would rather deal with such issues proactively, educating students and hopefully preventing them from committing illegal acts. As outlined earlier, judicial deference toward higher education has not been extended on this particular subject, making it critical for colleges and universities to take this issue seriously.

The first step for institutions may very well be to craft and enforce "acceptable use" policies. Kaplin and Lee (2007) asserted that the policy should be made available to the campus community online and that the policy should be posted in computer labs and copy centers in plain view of users. With the relatively recent and evolving nature of the legislation, as well as the fervor with which these illegal acts have been pursued, a direct and widely communicated institutional policy must be available to students, faculty, and staff. In March 2008, Temple University was yet another institution to inform all faculty, staff, and students of such a policy through a campus email entitled, "Policy Reminder on Copyright Violations." This memo focused on the legal ramifications of illegal downloading and offered individuals assistance in removing illegal files from their computers (Temple University, 2008). Realistically speaking, this will be an ongoing challenge for administrators on campuses to ensure all users are informed of this policy, especially given the pervasive nature of accessing digital files via the internet and the ease with which students can access this medium.

In addition, institutions must hold inclusive discussions of not only the legal implications of illegal file sharing, but also the ethical considerations of how to respond to requests for students named in lawsuits for illegal file sharing. These discussions also should include how to educate members of the campus community about fair use as part of a greater conversation on intellectual property, and legal ways to download and use digital files. Given students' relative immaturity and the potential consequences, an educational focus on ethical behavior along with the legal details of file sharing seems quite appropriate.

Through its Digital Citizen project at Illinois State University (ISU), a partnership of individuals and units from across their campus are involved in a research project to learn more about their students' use of P2P file sharing software. Through this research project, the authors attempted to turn anecdote to facts through research, and assert that illegal downloading is a symptom not the problem that is not incubated in higher education but inherited from K-12 (Illinois State University, 2007). Though in the early stages of their study, ISU researchers found that most students are somewhat aware of the legalities downloading digital media. Many students claim they would stop doing so illegally if caught, but would only stop for a few days. Although ISU chooses not to use packet-shaping software such as Packeteer to limit bandwidth to certain types of network activity, many campuses do just that in an attempt to curtail illegal P2P file sharing. One of the other hallmarks of this project is that ISU is partnering with RIAA, MPAA, as well as corporations that have a vested interest in reducing illegal file sharing by college students (Illinois State University, n.d.).

According to McCormick (2006), many colleges and universities are creating educational campaigns to inform their campus communities of the potential consequences of illegal P2P file sharing as well offering "free music download services to students as a legitimate, legal alternative to illegal P2P file-sharing" (p. 724). As mentioned, the question of what type of free downloading service and who should pay is still in question. It is difficult to define "offering," at least in terms of whether or not offering access to legal music services will be enough to placate the recording industry. Would it be enough if institutions simply had iTunes installed on all university-owned systems, both Mac OS X-based and Windows? On one hand, the institutions in question would provide easy access to the iTunes Store, which offers a wide variety of commercial audio and video content and numerous free songs, free episodes of television shows, and thousands of free audio and video podcasts. This strategy would require no additional costs, beyond the time needed to update the disk images of these systems. But, would such an undertaking be enough, or would institutions be required to actually purchase massive subscription plans for their students to services like the Microsoft Zune Marketplace, or the MTV URGE store? If so, wouldn't such an action effectively amount to a massive subsidization of the business model of a private industry by (in many cases) public institutions? Again, it goes back to how seemingly innocuous terms like *access* and *offer* are defined, and by whom. From a purely pragmatic perspective, Kaplin and Lee (2007) indicated that these efforts might be a good investment because, in their estimation, more colleges and universities have not been sued over the years because of their good-faith efforts to inform campus communities and respond to allegations of file-sharing infringement.

As one example, administrators at the University of South Florida (USF) recently informed users of a change to their campus network. Instead of completely blocking all P2P software from this campus network, or resorting to Draconian packet shaping measures, when a user attempts to use the university network to access P2P software, he/she is redirected to a web page, which reviews appropriate and legal P2P file sharing uses and to pledge they will not illegally download media files (Emerson, 2008). The university's vice president for information technology, Michael Pierce, said that instead of blocking all traffic to the P2P sites, USF wanted to make students aware using P2P software, because it can be used for legitimate purposes. If students violate this agreement and if they are named in an RIAA letter, they will be processed through the campus discipline process in which their sanction may be as serious as a suspension, as well as any legal penalties from their RIAA case. In addition, USF provides new students with information about this campus policy during orientation programs, in the residence halls, as well as through direct communications (Emerson, 2008).

This new system costs USF about $75,000 per year, which some argue should instead be spent for educational purposes. Other academics add that colleges and universities should not be coerced into spending taxpayer dollars in an attempt to stave off future law suits. Steve Worona, Director of Policy and Networking Programs for Educause, agrees with both arguments, saying that the time and money spent on blocking illegal downloads, which could be "tens of millions of dollars" nationwide, should be spent on educational needs as determined by individual institutions (Worona, in Emerson, 2008).

Many students and professors applaud these educational approaches as a means to stay ahead of the legislation and, they hope, lessen institutional liability. Though these approaches still allow the legitimate and beneficial uses of P2P software for faculty and students alike, some members of university communities are concerned that the overly restrictive measures regarding their campus networks could undermine the very foundation of academe. McCormick (2006) states, "Unfortunately, the collective effort of these measures, along with current statutory law, may have the unintended consequence of chilling the academic discourse vital to higher education's central goal and the technological innovation on which private industry has come to rely" (p. 725).

Slippery Slope

Colleges and universities will thrive to the extent that they foster innovation and the free exchange of ideas. The ability to do so is threatened by the emerging view of ideas as pure property and by a shift in focus from serving the public good to serving the bottom line. If we want to preserve innovation, we have to begin asking how we can share, rather than how we can protect. (Hilton, 2005, p. 73)

It is clear that institutions cannot permit or allow students to use campus networks to commit illegal acts of downloading digital media. The potential liability demonstrated in recent legislation and legal cases has made this painfully clear. However, institutions also have obligations to defend core values and be informed participants in this ever-important societal conversation. Harrison (2006) suggests the issues inherent in this conversation are timeless, and focus on "questions of ownership, intrusion into private lives, and ethical actions in the face of choices" (p. 708). McCormick (2006) echoes these thoughts: "Higher education must react to the changes in technology and the changes in laws in very technical ways, but our starting place should be grounded in basic fundamental questions, and with a goal to foster our academic purposes" (p. 682). It is critical for administrators and faculty in higher education to consider the ethical perspective in spite, and perhaps in the midst, of pressing legal threats.

Since 2000 when Metallica included three universities in its lawsuit against Napster, higher education has been reacting to and running from potential legal threats, often regardless of the infringing or noninfringing use of P2P software. Rather than taking an either/or position as many extremists have done, it is time for educators to do what we do best: respond to this societal issue by being true to our beliefs, which includes engaging interested parties in discussions on the protection of intellectual property, how technology has changed, and the way people view it, while maintaining a commitment to educate students along the way. Too much is at stake not to carefully consider the consequences of these threats. Harrison (2006) states: if higher education maintains a role to "educate first and discipline second, we can encourage and reinforce habitual respect for ownership and fair use" (p. 708).

Lisa McHugh Cesarini is the Assistant Vice Provost for Enrollment Management at Bowling Green State University.

Dr. Paul Cesarini is an Associate Professor and Chair of the Department of Visual Communication and Technology Education at Bowling Green State University, and is a Member-at-large of Epsilon Pi Tau.

References

American Council on Education (ACE). (March 11, 2008). ACE submits comments on file-sharing provisions in HEA reauthorization legislation. Retrieved March 13, 2008, from http://www.acenet.edu/AM/Template.cfm?Section=HENA&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=26000

Bono, M. (1998, October 7). Congressional testimony on the Sonny Bono Copyright Term Extension Act. Retrieved February 22, 2009, from http://thomas.loc.gov/cgi-bin/query/F?r105:1:./temp/~r105cSf1W8:e46923:

Carlson, S. (2000, April 28). Metallica sues universities and Napster, charging that students engage in music piracy. *Chronicle of Higher Education,* p. A50.

Creative Commons. (n.d.) Retrieved on March 30, 2008, from http://creativecommons.org/

Cornell University. (2007, April 11). Letter to all students regarding Recording Industry Association of America settlement letters and preservation notices. Retrieved on March 29, 2008, from http://www.cit.cornell.edu/policy/memos/riaa.html

Digital Millennium Copyright Act Report Executive Summary (DMCA). (n.d.) Retrieved February 28, 2008, from www.copyright.gov/reports/studies/dmca/dmca_executive.html

Emerson, A. (2008, March 20). USF keeps watch on students' music. *Tampa Tribune.* Retrieved March 28, 2008, from http://www2.tbo.com/content/2008/mar/20/na-usf-keeps-watch-on-students-music/

Hall, H. (2006). The day the music died: The Supreme Court's reversal of MGM Studios, Inc. v. Grokster and its impact on secondary liability for copyright infringement. *Journal of Law & Education, 35*(3), 387-393.

Harrison, D. (2006). The P2P file sharing war after Grokster: it feels like Belgium over here. *Journal of College & University Law, 32*(3), 681-708.

Heinlein, R. (1980). Life line. In R. Heinlein (Ed.), *Expanded universe*. (pp. 4-21). New York: Ace Books. (Original work published 1939).

Hilton, J. (2005). In praise of sharing. *Educause* Review, *40*(3), 72-73. Retrieved March 30, 2008, from http://connect.educause.edu/Library/EDUCAUSE+Review/InPraiseofSharing/40547

Hilton, J. (2006). The future for higher education: Sunrise or perfect storm? *Educause Review, 41*(2), 58–71.

Illinois State University (n.d.) Digital citizen project. Retrieved February 1, 2008, from http://www.digitalcitizen.ilstu.edu/

Indiana University statement (2000, April 20). IU installs filters preventing use of MP3 music site. Retrieved March 31, 2008, from http://newsinfo.iu.edu/OCM/releases/napster02.html

Jefferson, T. to McPherson, I. (1813, August 13). In Kurland, P. and Lerner, R. (eds.) *The Founders' Constitution.* Retrieved March 13, 2008, from http://press-pubs.uchicago.edu/founders/print_documents/a1_8_8s12.html

Kaplin, W. A., & Lee, B. A. (2007). *The law of higher education* (4th ed., Student version). San Francisco: Jossey-Bass.

LegalTorrents. *About Legal Torrents.* Retrieved August 11, 2008, from http://beta.legaltorrents.com/about

McCormick, B. (2006). The times they are a-changin': How current provisions of the Digital Millennium Copyright Act, recent developments in indirect copyright law and the growing popularity of student peer-to-peer file-sharing could "chill" academic freedom. *Journal of College & University Law, 32,* 709-725.

Morrill, D. (2006, October 6). Bit Torrent and Creative Commons. *ITtoolbox: Security Community.* Retrieved July 18, 2008, from http://it.toolbox.com/blogs/managing-infosec/bit-torrent-and-creative-commons-12265

Read, B. (2007, June 15). Lawmakers encourage colleges to use technology to curtail campus piracy. *Chronicle of Higher Education*, p. A34.

Recording Industry Association of America (RIAA) (2003). *Online Piracy and Electronic Theft Webpage.* Retrieved on April 4, 2008, from http://web.archive.org/web/20030801082948/www.riaa.com/issues/piracy/default.asp

SearchNetworking. *Traffic Shaping*. Retrieved on June 25, 2008, from

http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci1310157,00.html

Star Trek: Phase II. Frequently Asked Questions. Retrieved on August 1, 2008, from http://www.startreknewvoyages.com/faq.html

Temple University Campus Services memo. (March 26, 2008). *Policy reminder on copyright violations.* Retrieved March 29, 2008, from http://www.temple.edu/cs/VPannouncements/filesharingpolicy.html

Tech Encyclopedia. *Peer-to-peer network.* Retrieved on March 30, 2008, from http://www.techweb.com/encyclopedia/defineterm.jhtml?term=peer%2Dto%2Dpeernetwork

Ulrich, L. (2000). Music on the internet: Is there an upside to downloading? Testimony before the Unites States Senate Judiciary Committee. Retrieved on March 28, 2008, from http://judiciary.senate.gov/testimony.cfm?id=195&wit_id=252

United States Constitution. art. I, § 8, cl. 8. Retrieved March 18, 2008, from http://www.law.cornell.edu/constitution/constitution.articlei.html#section8

Digital Modeling in Design Foundation Coursework: An Exploratory Study of the Effectiveness of Conceptual Design Software

Stan Guidera and D. Scot MacPherson

Abstract

This paper presents the results of a study that was conducted to identify and document student perceptions of the effectiveness of computer modeling software introduced in a design foundations course that had previously utilized only conventional manually-produced representation techniques. Rather than attempt to utilize a production-oriented CAD program, this exploratory study investigated the use of alternative software applications developed by vendors specifically to function as conceptual design tools. The study was structured to identify areas of future investigation related to student perceptions of the effectiveness of the software in facilitating design exploration, the effectiveness and ease of use of various application features, and the extent to which prior CAD coursework was related to the perceived effectiveness of the software on design outcomes.

Introduction

The pervasiveness of computing in architectural practice poses challenges for design educators as faculty attempt to address the demands from practicing professionals for graduates who have greater competencies with digital technologies (Mitgang, 1999). The role of computing in architectural practice has evolved to CAD's becoming a baseline requirement for clients (Green, 2002). However, the emphasis of design education on developing design skills and promoting conceptual exploration has given rise to an ongoing debate among educators about the role of CAD and related digital tools in design curriculums. Further, it has been argued that the mandate of architectural education is to cultivate skills in life-long learning and that practice is where students develop technical knowledge (Karloff, 1996).

For educators attempting to integrate digital media in design courses, the criteria for selecting appropriate applications and tools for meeting course objectives is primarily subjective. More important, the literature on this topic commonly focuses on the success of students when using digital applications in design projects from the instructor's perspective, rather than from the novice designer's point of view. Therefore, research conducted to identify the extent to which students found software effective in the design process can provide insight into how digital design tools are best utilized by novice designers and assist design faculty in selecting appropriate digital applications to support intended course outcomes . In order to develop a basis for making such decisions, a study was conducted to begin to establish a knowledge base that could help identify and document student perceptions of the effectiveness of a software application.

To explore the use of an alternative to production-oriented CAD programs, this study was structured to investigate software applications developed specifically to function as conceptual design tools in introductory design courses. The study focused on student's perception related to the software effectiveness in facilitating design exploration, the effectiveness and ease of use of various application features, and the extent to which prior CAD skills were related to the perceived effectiveness of the software on design outcomes. Given the emphasis of these applications on ease of use, issues related to the influence of prior CAD skills on students perceptions were of particular interest.

All participants in the study were architecture majors enrolled in the second class of a two-course sequence covering concepts related to architectural representation and design foundations. Activities associated with the study took place during the final project of the course. The students were provided a project brief; they were required to use manual drawing and physical modeling in parallel with computer modeling using software developed for conceptual design in the development of their individual design solutions. Data was gathered using an instructor-developed survey administered at the end of the course. Instructor observation and statistical analysis of the survey data were used to develop an initial assessment of the perceived effectiveness of the software among students in the course.

Literature Review

Conceptual Design Processes and the Limitations of CAD

Sketching has traditionally been an integral activity in conceptual design. The importance of the sketch in the design process has been attributed to both its role in the iterative actions associated with conceptual design as well as to the contribution of ambiguity. Laseau (2000) discussed the importance of sketching as a means of facilitating "graphic thinking" in the design process, stating that graphic thinking facilitated a "communication loop" between the paper, the eye, the hand, and the brain, and that the potential of graphic thinking lies in the continuous cycling of information (p. 8). Goel (1995) referred to the sketch as a non-notational symbol system that promotes cognitive shifts from one proposed conceptual idea to other alternative concepts, a process he referred to as *lateral transformation*. He stated that "the general claim is that lateral transformations need to occur during the preliminary phase of design problem solving and that the density and ambiguity of the symbol system of sketching facilitate these cognitive operations" (p. 194) and cited the role of ambiguity in promoting lateral transformations or shifts between alternative concepts and solutions.

The visually ambiguous features of a sketch have been associated with the cognitive processes needed for design exploration. Won (2001) argued that during the drawing process designers demonstrate a "seeing behavior," in which they will concentrate on the figural properties of a , thus enabling the designer to "see the image as something else" (p. 324). Similarly, Suwa and Tversky (1997) proposed that sketches enable designers to "see unanticipated relations and features that suggest ways to refine and revise ideas" (p. 386).

In architectural design, CAD (computer-aided drafting or design) has become a primary medium for the development of construction drawings in professional practice. However, the inherent emphasis of CAD on precision has "accentuated the divide between explicit and implicit information" (Johnson, 1998). The pen or pencil sketch has retained its prominence as a design tool because it is exploratory rather than absolute, because it is inherently ambiguous, and because the degree to which the information it conveys is implied and subjective. Chastain, Kalay, and Peri (2002) argued that CAD is inherently unambiguous because its representations are explicit rather than implicit and therefore it is inappropriate for early stages of the design in which much of the effort is focused on conceptual characteristics.

The lack of ambiguity in computer-generated representations has lead to the view that computer applications are ineffective as design tools in the early stages of the design process where the priority is creativity (Van Elsas & Veergeest, 1998; Leglise, 1995; Suwa & Tvurskey, 1997). Jonson (2002) proposed that the strength of the freehand sketch lies in its economy of means (low cost) and immediacy (single-tool interface). He argued that a sketch carries less redundancy than a final drawing, stating that "when a sketch represents more than one possible interpretation, it could be seen as an explorative tool" (p. 248). This position directly contrasts with the purpose of a drafted image which has the intent of promoting the acceptance of a specific interpretationOutput generated with CAD applications is similarly viewed as lacking the ambiguity necessary to effectively promote the multiple interpretations and visual shifts in perception associated with design exploration in design processes (Won, 2001).

According to Bilda and Demirken (2003), CAD software works primarily on a "draw then modify" principle. From their research, they concluded that designers were more effective in using time, conceiving the problem, producing alternate solutions, and perceiving visual-spatial features and the organizational relations of a design in traditional rather than digital media during conceptual design. Other researchers have concluded that these limitations extend to other disciplines. In a study to investigate the comparison between traditional media and digital media among novice graphic designers, Stones and Cassidy (2007) concluded that working on a computer "seems not to be as effective, both in terms of fluency and variety, as drawing the form on paper" (p. 70).

The limitations of CAD in conceptual design also have been linked to the interface used. Designers typically use a mouse, a keyboard, and a 2D screen to interact with CAD systems. According to Ye, Campbell, Page, and Badni (2006), "the need to design and deploy new computer interfaces for the CAD system is evident, especially in support of conceptual design" (p.78).

3D Modeling and Digital Sketching Tools

According to Abdelhameed (2004), exploring design ideas through either two-dimensional or three-dimensional forms is the basis of design exploration and visual thinking during the design process. Whereas traditional media relied largely on sketching, 2D representations, and physical models for design exploration, computer-modeling tools have greatly expanded the ability of designers to develop 2D and 3D representations. For example, Simondetti (2002) investigated the implications of introducing computer-generated physical modeling in the early stages of the design process. He studied a design process that integrated sketching, computer modeling, and computer-generated physical modeling. According to Simondetti, this recursive process provided the following advantages: (1) understanding kinetic design, (2) understanding design involving complex geometry, and (3) understanding design at the interface with the human body.

Re-conceptualizing the Design Process to Optimize Digital Tools

Some researchers have suggested that the use of digital tools in conceptual design involves re-conceptualizing the design process itself in a way in which design with digital tools is perceived as involving an inherently different process. Abdelhameed (2004) argued that computing has "changed from being just a tool for drawing to being a medium through and by design which design is performed and solutions are generated" (p. 485). Bilda and Demirken (2003) proposed that "while digital media seems inconvenient for the conceptual design phase, this situation depends on the designer's designing habits" as well as limitations of the software (p. 49). Therefore, the argument that digital design tools are inappropriate for conceptual design may be reframed as an argument that the traditional design processes are mismatched to the digital media environment.

This re-conceptualization is reflected in arguments that propose that digital technologies be conceived as a design medium rather than a design tool. Oxman (2006) proposed that "interaction with computational design media requires of the designer a different form of input and level of formalization" and that "these distinctions between paper-based interaction with representations and digital interactions are significant both cognitively and theoretically" (p. 243). Sequin (2001) stated that the computer enabled artists to "to tackle structures of a level of complexity that clearly exceeded what an unassisted human could hope to achieve in the conceptual design phase as well as in the actual implementation of the final shape" (p. 345). He proposed that there was a "general trend to make computer based environments not simply a (still quite imperfect) emulation of real physical artist's tools, but to exploit some unique and novel services that only a computer can offer" (p. 347).

Conceptual Digital Design Environments

Conceptual design processes differ from other design phases such as design development and production, and typical digital design applications do not provide adequate support for all phases (Schodeck, Becthold, Griggs, Koa, & Steinberg, 2005). Effective conceptual design in a digital environment must rely on quick feedback from (digital) sketches, 3D modeling, and visualization. Conceptual modeling environments developed specifically for early design phases are "stand alone" sketching programs, geometric modelers, and renderers with an emphasis on initial shape generation that "employ line elements to facilitate the transition from traditional hand sketching to digital modeling" and often utilize interactive tablets for input in a manner similar to sketching on paper (Schodeck, Becthold, Griggs, Koa, & Steinberg, 2005, p. 193).According to Schodeck, Becthold, Griggs, Koa, & Steinberg (2005), "these environments must be simple to learn, easy to use, and not impose limits" (p. 192), This approach is consistent with proposals that suggest that conceptual digital design environments should emulate or parallel manual sketching (Bilda & Demirkan, 2003; Jonson, 2002).

Summary

The literature suggests that digital design tools that were developed specifically for conceptual design may provide substantive benefits over attempts to utilize conventional CAD in early design phases. In addition to ease of use and learning, stand-alone sketching programs provide the benefits of a nontraditional medium for design exploration supported by parallels with more traditional media. Consequently, this study was developed to investigate how a conceptual digital design application could be utilized by novice designers in an academic setting.

Methodology

As an exploratory study, the research methodology was structured to document student perceptions of the effectiveness of conceptual design software effectiveness in a design foundations course and also to investigate approaches to conducting the research and analysis. The study was structured to address the following research questions:

1. Does CAD experience influence the perceived effectiveness and use of the software? The null hypothesis for research question one was that prior CAD experience does not influence the perceived effectiveness and use of the software.

2. To what extent was the use of this software application perceived to influence the design process? The null hypothesis for research question two was that \the software was not perceived to influence the design process.

3. What software tools/features/operations were perceived as effective and/or easy to use?

Research Design

The research design for this study was structured to utilize a mixed methodology; quantitative data collected with a survey instrument was supported by supplemental data collection by the class instructor in the form of instructor observations and logs. It was the intention of the researchers that the instructor's observations would be used to provide insights into the survey responses and analysis of the quantitative data collected with the survey instrument.

Population & Sample

The study participants were students enrolled in the second course of the two-course architectural representation and design foundations sequence of the four-year Bachelor of Science program at a public university. This required class was offered once per academic year, open only to second-year architecture majors. The study population was a convenience sample; therefore, there was no attempt to randomly select participants from a larger group as the students were selected based on their enrollment in a specific course which would have required prior coursework involving manual drawings and physical models. This decision was based on the conclusion that students had to some extent developed skills with design concepts, composition, drafting, and model building, which would provide a reference for their perception of the software effectiveness. Additionally, the course typically included a mixture of students with CAD skills and those without, therefore providing the potential for responding to the research question related to the influence of CAD experience.

Instrumentation

A survey was developed by the researchers to collect data related to the research questions. .Instructor's observations were documented during the duration of the class activity. The survey utilized a series of Likert questions which documented the participants' experiences using the software in the study activities. However, it should be noted that the instrument was not pilot tested nor were reliability checks conducted for the Likert items. The questions were used to collect data on the participants' CAD experience, and the influence of CAD skills in learning and using the software. The questions also were used to collect data on the participants' perceived effectiveness of specific software features, tools, and operations, as well on the participants' perceptions of the ease of use of various features and operations. Additional questions were used to collect data on the participants' perceptions of the influence that this software had on their design process, and of the effectiveness of the software as a design and communication tool.

The majority of the survey questions were based on a five-point rating scale. For questions intended to collect data on perceived effectiveness, the responses were "very effective" (5), "effective" (4), "neutral" (3), "ineffective" (2), and "very ineffective" (1). For questions intended to collect data on perceived ease-of-use, the responses were "very easy" (5), "easy" (4), "neutral" (3), "difficult" (2), and "very difficult" (1). Data was also collected for these categories with questions requiring a response of "strongly agree" (5), "agree" (4), "neutral" (3), "disagree" (2), or "strongly disagree" (1).

Statistical Analyses

Statistical analyses were employed to answer the research questions for the study. The use of Likert-style questions limited the quantitative analysis to tests appropriate for ordinal data. To test for significant ratings above or below neutral, a single-sample t test with a test value of 3.00 was used to analyze the mean of the responses to each question. The confidence interval used for all tests and analysis was .95 (a =.05).

Nonparametric correlation tests were used to analyze responses for all variables. Despite the inherent limitations associated with the use of nonparametric tests with the small size of the study population and assumption that the data was normally distributed, it was anticipated that cross-tab and correlation test could provide additional insight into the t-test results. Additionally, analysis using crosstab and correlation tests in the exploratory study could assist in evaluating the structure of the survey questions and identifying minimum study population sizes required for further research.

For analysis of CAD experience and skill level three primary variables were used. First, the participants were asked to identify the number of CAD courses they had taken in both high school and college. This provided a measure that was to some degree objective. Second, they were asked to indicate their perception of their CAD proficiency using a Likert-item with a ranking of very proficient, proficient, moderate, minimal, or no experience. Lastly, the participants were also asked to indicate the extent to which they perceived their CAD skills to be useful in using the software on a Likert scale ranging from 1, not at all useful, to 5, very useful. Students with no prior CAD skills were excluded from the statistical analysis.

To determine the extent that the software was perceived to influence the design process, the survey included questions which asked the participants to rate the extent to which they perceived the use of the software had a positive effect on design outcomes and had a positive effect on design communication. Participants were also asked to rate the extent they perceived that the use of the software influenced their use of forms in the model and to rate the extent to which they believed they were able to create all the forms they intended to use in their model.

To determine the perceived effectiveness of specific software features and operations, participants were asked to rate the effectiveness of the software relative to a variety of features and operations, including:

1. The use of the workspace and grid snap
2. The use of object handles or grips to reshape or resize an object
3. The use of object handles or grips to reposition an object
4. The ability to add shadows to the display
5. The ability to change to plan or elevation views

The ratings ranged from very effective (5), to very ineffective (1), with a rating of 3 indicating neutral. An additional response of "I did not use this feature" was also provided. These responses were excluded from the data analysis. Other operations were similarly rated for ease of use using a five-point ranking of five for "very easy" to one for "very difficult," with a ranking of 3 indicating neutral. The operations were:

1. Creating rectangular/box-shaped volumes
2. Creating curvilinear-shaped objects
3. Creating objects with accurate and/or specific dimensions
4. Using the grid tools to create objects at specific locations
5. Using the grid tools to create objects with specific dimension
6. Accurately re-positioning objects and forms in space
7. Accurately placing/positioning objects and forms relative to other objects and/or forms
8. Accurately placing/positioning objects at varying elevations or heights.

Additionally, other operations were rated for perceived effectiveness using a five-point ranking of five for "strongly agree" that the operation was effective to one for "strongly disagree" that the operation was effective, with a ranking of three indicating neutral. The operations were:

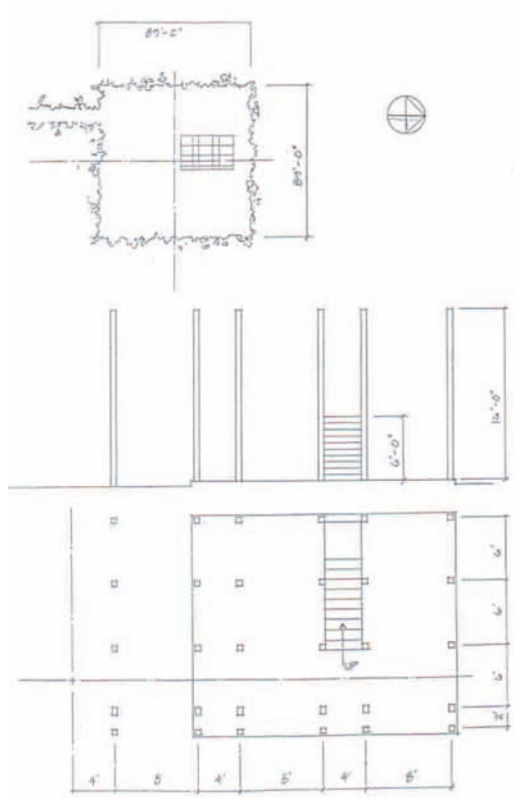
1. Interface/commands facilitated precise positioning/placement of objects.
2. Interface/commands facilitated precise re-positioning/movement of objects.

Data Collection Procedures

The researchers utilized a design project in a second-year, first-semester design foundations course as the source for data collection related to the research questions. The project was selected because it had sufficient duration to enable the faculty to allocate time to introducing the software as part of the course activities. The project brief required students to design a structure that "was enclosed but not enclosed" within a predefined context that included a pre-existing slab and column grid located in a flat rectangular open space surrounded on all four sides with dense trees. This was intended to provide the students with a pre-existing ordering system (the column grid) and a well-defined site perimeter (the wooded perimeter). The pre-existing components were to be integrated into their design (Figure 1).

Initial class activities were directed towards exploring responses to the project brief and included manual sketching and development of physical models. As the students continued to use sketching and physical modeling, class time was allocated to introduce them to Autodesk's Architectural Studio software, a conceptual design application that included a variety of 3-dimensional modeling tools. The software modeling tools included the capability to create 3D shapes using primitive objects such as cubes, spheres, and cylinders, and objects that could be created using free-form spline-based sketching tools. The software included a grid-snap feature (workspace grid) and the capability to easily create a user-defined grid on object-surfaces. The interface incorporated references to conventional drawing and drafting media and techniques. The drawing tools included both freehand sketching emulation as well as basic 2D geometry commands used to create lines and shapes such as arcs and rectangles. This enabled students to utilize practices that had been promoted in class, including techniques such as overlaying layers of tracing paper and icon-based drawing tools with a functionality that at least to some extent paralleled pencil and felt markers used in the course. The use of interface elements that parallel conventional design representation techniques and processes is aligned with the parameters for digital conceptual design applications proposed by Bilda and Demirkan (2003). All students used identical computers configured with a mouse as the input device.

Figure 1. Study Project Handout



Two software training sessions were conducted over the duration of the assignment. During and after the initial session, students were required to work with the software independently of the course project in order to produce freeform compositions which incorporated both rectangular and curvilinear forms. After the second session, the students were asked to experiment by re-creating their course projects and developing them further using the software tools. For their final project submission, students were instructed they could utilize images generated from the computer model to supplement to their physical models and manually drafted documentation.

The Survey was administered at the end of the primary design activities for the project, but prior to the student's final presentation. This enabled students to have sufficient experience with the software to provide informed responses to the questions on software features as well as their overall experience in using the application as a design tool. Although the survey was administered during class time, students were informed that participation in the study was voluntary.

Supplemental data was collected using logs or journals of the instructors' observations during training sessions and also during nonstructured studio activities. These writings primarily focused on documenting commonly used features, commonly used command or software operation sequences, and aspects of software operations that students found to be more time-consuming or difficult.

Findings

Assumptions and Limitations

Because of the small study population size, the extent to which the findings can be generalized is inherently limited, and, since the study was structured around the operation and features of one software application, the generalization of conclusions to other applications is limited as well. It should be noted that any conclusions related to non parametric tests conducted on responses associated with prior CAD skills, an area of interest in this study, was further limited because students with no prior CAD skills were excluded from the statistical analysis, further reducing the sample size.

The study population was also a convenience sample in that the students were selected in terms based on their status as novice designers in the architecture program at a specific institution, and their access to labs with the required software installed. Therefore, it could not be assured that this sample was an accurate representation of some larger group or population. Additionally, the use of Likert-scale questions assumed that data was normally distributed and that all participants utilized a similar interpretation of the available categories and terminologies when responding to the questions. It was also assumed that there was only limited influence of the Hawthorne effect (Brannigan & Zwerman, 2001), which assumes that responses to the survey items were influenced by participation in the study. Lastly, as the instructor's observations were intended to be supplemental to the primary data collection using the survey instrument, these observations were assumed to be anecdotal in the absence of a data-collection structure which supported more rigorous qualitative analysis.

Figure 2. Initial Experimentation (1st Session): Perspective and Plan View

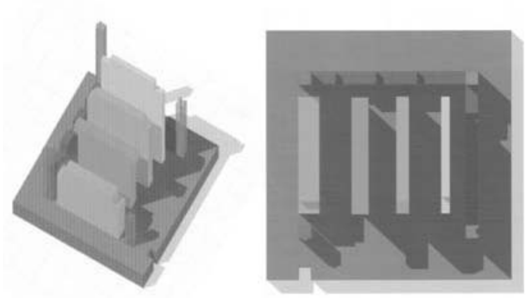
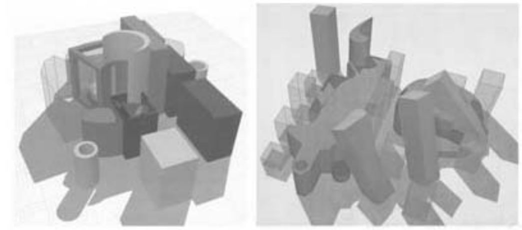


Figure 3. Software Experimentation (2nd Session)



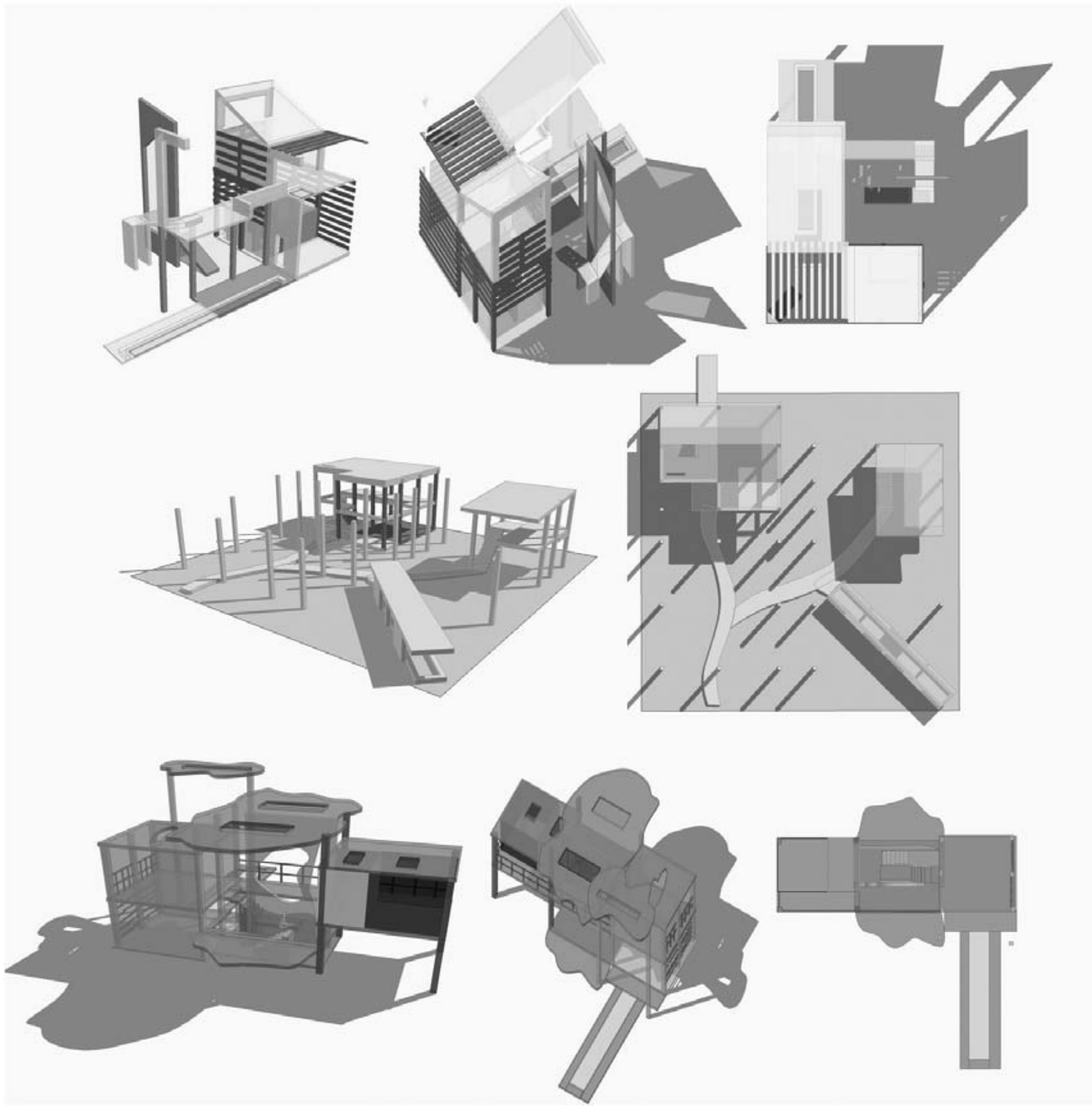
Instructor Observations

All participants in the study appeared to be able to navigate the menu selections and create basic geometry with little difficulty. The primary modeling approach was to place objects, initially using only rectangular-shaped volumes, using the default predefined object height (10 units) and then manipulate the geometry to the desired height, as well as length and width. In the initial explorations, students primarily utilized manipulations of height in the z direction with very limited manipulation of geometry off-axis relative to x, y, and z axis (Figure 2). Students appeared to utilize the ability to switch between orthographic and perspective views and also to utilize shadows and the ability to manipulate object transparency. Some students had difficulty with the zoom features when experimenting with "field of view" options. Students would "get stuck" in perspective view after incorrectly performing zoom operations that produced a very wide field of view, resulting in a distorted on-screen view of their geometry. The students did not utilize software features that paralleled manual drafting, including the sketching tools such as multiple pens for variations in line weight and style. Additionally, no students were observed using sketch overlays. During the second training session more experimentation with curved forms and off-axis geometry was observed (Figure 3). The use of the ground plane grid and grid-snap tools increased, as did attempts to use more precision in creating 3D geometry, a factor largely associated with attempts to begin to use the software to build a computer model of their project. For the final project submission, most students included supplemental computer images when presenting their work. It was noted that nearly all submissions incorporated shadows and included plan or elevation views in the output (Figure 4).

Data Analysis

A total of 24 students were in the class, and 23 participants completed the survey (N = 23). 15 participants (65.2%) indicated they previously had taken at least one CAD class. Of these, seven (30.4%) had taken one class, three had taken two classes, and one had taken three or more classes. The participants self-identified skill level was documented as follows: seven indicated that they had no CAD skills, four

Figure 4. Final Project submissions.



indicated their CAD skills were minimal, 10 indicated their CAD skills were moderate, and one indicated proficiency with CAD. These results indicate consistency between reported CAD skills and number of CAD courses. One participant did not respond to these two questions, but did submit the survey and respond to the other questions on the survey. These responses are documented in Table 1 and Table 2.

One sample t-tests yielded several statistically significant results. T-test's for the variables rating overall ease-of-use and overall ability to learn the software found a positive mean difference of .64 ($p = .002$) and 1.05 ($p = .000$) respectively. For specific tools and features, statistically significant ratings were found for the effectiveness of workspace grid settings ($p = .000$), the effectiveness of handles or grip effectiveness to re-size objects ($p =.000$), the effectiveness of handles or grip to re-position objects ($p = .000$), the ability to rotate objects ($p = .001$), , the ability to add shadows ($p = .000$), the ability to change to plan or elevation views ($p = .000$), and creating rectangular volumes ($p = .000$). T-tests found that mean difference of the rating for the perception that the software influenced the forms used in the participants designs was also significant at the .01 level ($p = .000$). Additionally, no significant mean difference for the perception that the participants were able to create all the forms they needed ($p = .576$),

Table 1 Respondent CAD Class Experience (N = 23)

No prior CAD classes	One prior CAD class	Two prior CAD classes	Three or more prior CAD classes	No Response
7	11	3	1	1

Table 2 Respondent CAD skill self-assessment (N = 23)

No CAD skills	CAD skills: Minimal	CAD skills: Moderate	CAD skills: Proficient	No Response
7	**4**	**10**	**1**	**1**

suggesting a largely neutral rating for this variable. Features and operations that generally related to accuracy and precision were found to be not significant or in some cases to have negative mean differences, indicating an unfavorable rating.

Although the small study population limited the interpretation of the results of nonparametric tests, the analysis were conducted in an attempt to identify areas in which both the study and the survey instrument could be improved. Cross-tab analysis of the responses yielded statistically significant relationships between the perceived usefulness of previous CAD skills and the ease-of-use of the software to modify objects to specific dimensions (-.505, p = .002), and ease-of-use of the grid tools to create objects with specific dimensions (-.359, p = .036). A significant relationship was found between perceived CAD skill level and ease-of-use of the software to create curved forms (.419, p = .035). Similarly, analysis using bivariate correlations (Kendall tau b) yielded a significant negative correlation between the perceived usefulness of previous CAD skills and the ease-of-use of the software to modify objects to specific dimensions (-.505, p = .016), and a positive correlation for ease-of-use of the software to create curved forms (.419, p = .047). Bi-variate correlation analysis yielded a significant negative correlation between number of CAD classes and the ease of use of the software in placement and positioning objects (-.588, p = .014).

Cross-tab analysis yielded statistically significant relationships between perceptions that the software had a positive effect on design outcomes and perceived overall software ease-of-use (.463, p = .006), the effectiveness of the software for facilitating students in creating forms and shapes needed for their designs (.518, p = .009), and the effectiveness of the software for communicating their design (.452, p = .030). Bivariate correlation analysis found statistically significant relationships between perceptions that the software was positive for communicating their final project (.452, p = .024), and the effectiveness of the software tools and operations for creating all the forms they intended for their design (.518, p = .010). When considering specific tools and features/operations, bivariate correlations were found between perceptions that the software had a positive effect on design outcomes and workspace and grid setting features (.523, p = .009), the effectiveness of object-handles or grips to re-size objects (.678, p = .001), the effectiveness of the interface and commands for precision in object placement/positioning (.435, p = .026), and the effectiveness of the interface and commands for precision in object relocation/re-positioning (.631, p = .001).

Conclusions and Recommendations

Analysis of the responses suggested for this group of students CAD skills, did not appear to have a positive influence on the use and operation of the software, thus resulting in the null hypothesis for research question one not being rejected. It could be assumed that for these students' experience using CAD software, which would typically include commands that employed a high degree of accuracy and precision, was not easily translated to the modeling tasks using this type of application. Therefore, the data and observations in this exploratory study suggested that CAD skills may not be essential to the introduction of this type of application in this course and that the introduction earlier in the curriculum, at which time several students may have not had any CAD training or experience, may actually be favorable. Such a conclusion cannot be generalized to other students or curriculum because of the use of a convenience sample and a small study population in this exploratory study.

The responses suggested participants seemed to view the software positively influencing the project design and communication, thus rejecting the null hypothesis for research question two. Even though it is necessary to consider the limitations of nonparametric tests in the context of this study, the positive correlations found between the perception that the software had a positive effect on design and the perceived ability to create all forms needed for the design indicated this study population likely perceived the software most effective were those who were most successful at developing the competencies they needed to model their projects.

The students' responses suggest that the software was to some extent perceived as easy to use and learn, as indicated by the ratings for these variables. However, these exploratory findings also suggested that on the whole the students were neutral in their rating of their ability to develop the required competencies; anthey also may have believed the software did influence their designs. The data does suggest that the participants found certain tools and features more effective than others. For example, the survey responses and the instructor's observations suggested that the novice designers in this course with no CAD experience had the greatest difficulty in creating computer models with precise dimensions and in creating curvilinear forms. Arguably, since creating curvilinear forms involves more complicated processes than creating rectilinear forms, it could be assumed that curved forms required greater technical competencies because this is the single variable where the positive influence of CAD skills was most evident. This result suggests that for inexperienced students faculty may still find it necessary for allocation of time to learning activities specifically associated with dimensional precision and more complex object modeling tasks are recommended in order to minimize the extent these features would be perceived as obstacles to design exploration.

Inventory of recommended features

The combination of the data sources, classroom observations, and student comments suggested that some 3D modeling tools and features were perceived to be either more effective or easier to use than others. Additionally, the extent of use of several tools and features also suggested preferences among the participants.. Therefore, the study suggests that educators considering integrating digital modeling tools should consider applications that include the features described in the following paragraphs:

Direct Geometry Manipulation

The data indicated that the novice designers in the study preferred to directly manipulate the geometry, as evidenced by the statistically significant effectiveness ratings for the operation of handles and grips. This was supported by instructors' observations, specifically in relation to the commonly observed technique of first creating an object and then modifying and manipulating the object to the desired dimension and location.

Grid Tools

The data also indicated that grid tools on both objects and workplace were utilized and considered effective. It is likely that the grid-snap tools provided a means by which students could create and align objects with precision without relying on typing in specific coordinates. However, it should be noted that although not statistically significant, correlation tests found negative correlation between perceived CAD skills, number of CAD classes, and the perceived usefulness of CAD skills and ratings for all questions related to effectiveness of the grid and workspace tools. Though the study did not document perceptions of the effectiveness and ease-of-use of coordinate entry, alternative methods of placement and manipulation may be considered an important feature.

Orthographic Views

It was observed that the ability to easily change between perspective and orthographic views was utilized extensively by the participants. This feature was also used for generating output at various stages during the assignment. One-sample t-tests found the mean difference of the rating for the effectiveness of the ability to change to orthographic views was significant at the .01 level ($p = .000$). The data also suggested an association between the perceived effectiveness of this feature and the ability to learn to use the software (.455, $p = .006$). While the combination of observation, output, and data analysis suggested that this feature is effective, utilizing orthographic views in a digital design tool can also serve to make connections with related coursework and course activities that employ drafting techniques and other similar terminology.

Shadow Display

The data suggested that the display-shadow option was widely utilized in the assignment for output generated during the training sessions and for display of the participant's solutions to the design problem. One-sample t-tests found the mean difference of the rating for the effectiveness of the ability to use shadows was significant at the .01 level ($p = .000$). The perceived effectiveness of the ability to use shadows was significantly correlated with perceived ability to learn the software (.360. $p = .025$) and with the perceived effectiveness of the software in accurately placing objects at varying elevations

(.555, p = .000). The study did not yield any data that suggested an explanation and no assumptions can be directly inferred from the documentation. However, given the extensive use of shadows observed suggested that this feature was utilized to an extent that it may be an important option in any application used in a design course.

Survey Instrument and Methodology Modifications

The results of this exploratory study suggest several adjustments in methodology and in the survey instrument. In future studies a minimum study population size of approximately 48 would be more appropriate in order to assure minimum cell counts required for many nonparametric tests. Along with the increased population size, analysis should also include distribution tests to determine the extent to which assumptions of normal distributions can be made to more effectively support any interpretations and conclusions. Analysis of responses that used t-tests should also be expanded. Since a one-sample median test allows for testing to determine if a sample median differs significantly from a hypothesized value, future studies should consider median t-tests in addition to mean t-tests in order to more effectively support conclusions.

Several recommendations for modifications to the survey instrument arose from the analysis related to the nonparametric statistical analysis used in this study. Most of these modifications were related to the size of the study population. For nonparametric tests, restructuring the Likert questions from five items to three would more likely yield tests results that met the minimum number of responses required in future studies with small populations. Additionally, the instrument used in this exploratory study was structured to collect data using t-tests and nonparametric tests. Questions should be restructured to collect data that can be more clearly associated with a specific statistical test associated with a specific research question rather than attempting to the somewhat uniform approach to all research questions and tests that was employed in this study. Lastly, since the role of CAD experience was an area of interest in this study, in future studies the instrument should be modified to collect additional demographic data related to prior CAD experience in order to provide a more thorough description of the participants' skill sets. In larger studies, this change could assist in identifying similarities, differences, and subcategories among the students with CAD experience in order to draw more informed conclusions related to comparisons between students with CAD experience and those without.

Areas for Further Research

The study findings suggest that digital design tools can be integrated in such courses without CAD skills or related technical knowledge as a prerequisite, and that these applications can serve to facilitate design exploration and communication for novice designers. However, additional empirical research into the perceived effectiveness of conceptual design software in design foundations courses is necessary to substantiate the findings of this exploratory study. The initial analysis provides insight into the influence of some of the variables that could affect student performance and success in meeting intended studio learning outcomes. Specifically, investigations with larger populations that compare alternative software applications could assist faculty in identifying the features in common among the applications that proved to be perceived as most effective by users. Expanding the investigation to include multiple disciplines may provide insight into the fields and areas of study in which these applications held potential for enhancing outcomes. Additionally, given the data and the instructors' observations, the findings related to use of features such as direct geometry manipulation suggest investigations of the role of alternative input devices may be appropriate as well in order to identify ways faculty could optimize digital conceptual design tools in academic environments.

Dr. Stan G. Guidera is an Architect and Associate Professor in the Department of Architecture & Environmental Design at Bowling Green State University, Ohio, and a member of Alpha Gamma Chapter of Epsilon Pi Tau.

Scot McPherson is a Lecturer in the Department of Architecture and Environmental Design at Bowling Green State University, Ohio.

References

Abdelhameed, W. (2004) Visual design thinking in the design process as impacted by digital media, architecture in the network society [22nd eCAADe Conference Proceedings / ISBN 0-9541183-2-4] Copenhagen (Denmark) 15 - 18 September 2004, pp. 90 - 94 http://cumincad.scix.net/cgi-bin/works/Show?2004_090

Bilda, Z., & Demirken, H. (2003). An insight on designers' sketching activities in traditional versus digital media. *Design studies, 24*(1), 27– 50.

Brannigan, A., & Zwerman, W. (2001). The real hawthorne effect, *Society, 38*(2): 55 - 60.

Chastain, T., Kalay, Y., and Peri, C. (2002). Square peg in a round hole or horseless carriage? Reflections on the use of computing in architecture. *Automation in Construction, 11*(2), 237 – 248.

Goel, V. (1995). *Sketches of thought.* Cambridge: MIT Press.

Green, K. (2002). How client values affect architect selection. J. Demkin, Ed. *The architects handbook of professional practice, student edition,* (13th. ed.). New York: Wiley.

Johnson, S. (1998). What's in a representation, why do we care, and what does it mean? Examining evidence from psychology. *Automation Construction, 8*(1), 15 – 24.

Jonson, B. (2002). Sketching now. *Journal of Art Design and Education, 21*(3), 246 – 253.

Karloff, R. (1996). How the profession is failing the schools. *Architecture* (85).

Laseau, P. (2000). *Graphic Thinking for Architects & Designers* (3rd. ed.). New York: Wiley.

Leglise, M. (1995). Art under constraint – Preserving the creative dimension in computer-aided architectural design. *Languages of Design, 3*(1), 55 – 72.

Mitgang, L. (1999). Back to School: Architects sound off on 10 critical issues facing architectural education. *Architectural Record.* September 1999, 112 – 114.

Oxman, R. (2006). Theory and design in the first digital age. *Design Studies, 27*(3), 229-265.

Schodeck, D., Becthold, M., Griggs, K., Koa, K., & Steinberg, M. (2005). *Digital design and manufacturing: CAD/CAM applications in architecture and design.* (1st. ed.). New York: Wiley

Sequin, C. (2001) CAD and the arts. *Computer-Aided Design, 33*(5), 345-348.

Simondetti, A. (2002). Computer-generated physical modeling in the early stages of the design process. *Automation in Construction, 11*(3), 303-311.

Stones, C., & Cassidy, T. (2007) Comparing synthesis strategies of novice graphic designers using digital and traditional design tools. *Design Studies, 8*(1), 59-72.

Suwa, M., & Tyersky, B. (1997). What do architects and students perceive in their design sketches? A protocol analysis. *Design Studies, 18*(4), 385 - 403.

Van Elsas, P. & Vergeest, J. (1998). New functionality for computer-aided design: The displacement feature. *Design Studies, 19*(1), 81 - 102.

Won, P. (2001). The comparison between visual thinking using computer and conventional media in the concept generation stages of design. *Automation in Construction, 10*(1), 25 - 35.

Ye, J., Campbell, R., Page, T., & Badni, K. (2006) An investigation into the implementation of virtual reality technologies in support of conceptual design. *Design Studies, 27*(1), 77 - 97.

The 2007 Paul T. Hiser Exemplary Publication Award Co-Recipients

Al Bellamy

"Exploring the Influence of New Technology Planning and Implementation on the Perceptions of New Technology Effectiveness"

And

Mark R. Snyder

"The Education of Indentured Servants in Colonial America"

The Board of Editors of The Journal of Technology Studies and the Board of Directors are pleased to announce the co-recipients of the Paul T. Hiser Exemplary Publication Award for Volume XXXIII, 2007.

The Board of Directors established this award for deserving scholars. In recognition for his exemplary service to the profession and to the honorary as a Trustee and Director, the award bears Dr. Hiser's name. It is given to the author or authors of articles judged to be the best of those published each year in this journal.

Selection Process

Each member of the Editorial Board recommends the manuscript that he or she considers the best of those reviewed during the year. The editor forwards copies of nominated manuscripts to the members of the board for their evaluation against the criteria. A majority vote of the editors is required for the award to be made. The honor society's Board of Directors renders final approval of the process and the award.

Criteria

1. The subject matter of the manuscript must be clearly in the domain of one or more of the professions in technology.

2. The article should be exemplary in one or more of the following ways:
    - Ground-breaking philosophical thought.
    - Historical consequence in that it contains significant lessons for the present and the future.
    - Innovative research methodology and design.
    - Trends or issues that currently influence the field or are likely to affect it.
    - Unique yet probable solutions to current or future problems.

A $300 award recognizes the recipient(s) for the year and is presented during an Epsilon Pi Tau program at an annual professional association conference.

GUIDELINES FOR The Journal of Technology Studies

A refereed publication of Epsilon Pi Tau the international honor society for professions in technology.

The Journal of Technology Studies (JOTS) is the flagship, peer-reviewed journal of Epsilon Pi Tau, an international honor society for technology professions. Two print issues per year are mailed to all members of the society as well as to academic and general libraries around the globe. These printed issues, plus additional issues available only in electronic format as well as past issues, are available free on-line at scholar.lib.vt.edu/ejournals/jots.

SUBJECT FOCUS

The JOTS welcomes *original* manuscripts from scholars worldwide focused on the depth and breadth of technology as practiced and understood past, present, and future. Epsilon Pi Tau, as perhaps the most comprehensive honor society among technology professions, seeks to provide upto-date and insightful information to its increasingly diverse membership as well as the broader public. Authors need not be members of the society in order to submit manuscripts for consideration. Contributions from both academics and practitioners are equally welcome.

A general guide to the breadth of topics of potential interest to our readers can be gained by consideration of the 17 subclasses within "Technology" of the classification scheme of the Library of Congress, USA <lcweb.loc.gov.catdir/cpso/lcco/lcco_t.pdf>. This includes engineering and allied disciplines, informatics in its many manifestations, industrial technology, and education in and about technology. Authors are strongly urged to peruse this list as they consider developing articles for journal consideration. In addition, JOTS is interested in manuscripts that provide:

- brief biographical portraits of leaders in technology that highlight the difference these individuals made in distinct fields of technology or its wider appreciation within society,
- thoughtful reflections about technology practice,
- insights about personal transitions in technology from formal education to the work environment or vice versa,
- history, philosophy, sociology, economics, and anthropology of technology,
- technology within society and its relationship to other disciplines,
- technology policy at local, national, and international levels,
- comparative studies of technology development, implementation, and/or education,
- industrial research and development,
- new and emerging technologies and technology's role in shaping the future.

Within this immense diversity of technology, its applications and import, authors must communicate clearly, concisely, informatively, and only semi-technically to readers from a diverse set of backgrounds. Authors may assume some technical background on the part of the reader but not in-depth knowledge of the particular technology that is the focus of the article. Highly technical articles on any field of technology are not within the purview of the journal. Articles whose subject focus has been extensively explored in <u>prior</u> issues of the journal are only of potential interest if they: 1) open up entirely new vistas on the topic, 2) provide significant new information or data that overturns or modifies prior conceptions, or 3) engage substantially one or more previously published articles in a debate that is likely to interest and inform readers. Syntheses of developments within a given field of technology are welcome as are metanalyses of research regarding a particular technology, its applications, or the process of technical education and/or skill acquisition. Research studies should employ methodological procedures appropriate to the problem being addressed and must evince suitable design, execution, analysis, and conclusions. Surveys, for example, that exhibit any or all of the following characteristics are of no interest to the journal: 1) insufficient awareness of prior research on this topic, 2) insufficient sample size, 3) improper survey design, 4) inappropriate survey administration, 5) high mortality, 6) inadequate statistical analysis, and/or 7) conclusions not supported by either the data or the research design employed. The journal is neutral in regards to qualitative, quantitative, or mixed method approaches to research but insists on research quality.

GUIDELINES FOR The Journal of Technology Studies (Continued)

GUIDELINES FOR SUBMISSION

Articles must conform to the most current edition of the Publication Manual of the American Psychological Association. All articles must be original, represent work of the named authors, not be under consideration elsewhere, and not be published elsewhere in English or any other language. Electronic submissions in either rich-text format or Microsoft Word formats are encouraged, although submission of three printed copies and a diskette containing the article are also permissible. E-mail submissions should be sent to the editor, Dr. Dominick Fazarro, at jots@bgsu.edu. Paper submissions should be mailed to:

Editor, Journal of Technology Studies
Epsilon Pi Tau, Technology Building
Bowling Green State University
Bowling Green, Ohio 43403-0296

Manuscripts should be no more that 25 pages, double spaced, including references. Typescript should be *Times New Roman* or a close approximation of font and 12 point. Only manuscripts in the English language will be accepted and they should conform to American usage. Figures, tables, photographs, and artwork must be of good quality and conform to APA form and style.

REVIEW PROCESS

Articles deemed worthy by the editor for consideration by Authors who submit an article that does not merit review by the editorial board are informed within approximately two weeks of receipt of the article so that they may explore other publishing venues. A rejection may be based solely on the content focus of the article and not its intrinsic merit, particularly where the topic has been extensively explored in prior JOTS articles. Articles that exhibit extensive problems in expression, grammar, and spelling are summarily rejected. Authors of articles that have been peer-reviewed are informed within about three months from the date of submission of the article. Anonymous comments of reviewers are provided to authors that are invited to submit a revised article for either publication or a second round of review. The editor does not automatically provide reviewer comments to authors whose articles have been rejected via the peer review process but makes a judgement based on whether the feedback might prove beneficial to the authors as they pursue other publishing opportunities.

PUBLICATION

Authors whose articles have been accepted, will have their final products published in the on-line version of the journal. Selected articles from the on-line edition of the journal may also appear in two print issues that are issued per calendar year. All authors will receive a pdf version of their published article and co-retain rights to that article along with Epsilon Pi Tau. The editor will supply when requested information about an accepted article that has not yet appeared in print for faculty undergoing tenure review.

NOTE: - high relationship, - low relationship.