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Bits and Pieces

FROM THE EDITOR

Welcome, Readers, to Volume 45 Number 1 Spring 2008 of the Journal of Industrial Teacher Education (JITE). As mentioned previously in his column, Volume 45 marks the inauguration of the three issues per volume publication cycle with Fall 45.2, and Winter 45.3 to follow.

Although not planned as a theme issue, the articles that await you align themselves with the foundational elements of the teaching/learning continuum: What to Teach, How to Teach It, and How to Assess It. Kara Harris and George Rogers lead off with their Delphi study focused upon, "…what qualities and competencies high school students should possess upon entering into freshman engineering programs" (p. 6).

Paul Asunda and Roger Hill pick up the How To Teach It aspect within their article Preparing Technology Teachers to Teach Engineering Design. As they clearly state, "The purpose of this study was to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education" (p. 26).

Lynna Ausburn and Floyd Ausburn continue the same aspect with their examination of the potential of virtual reality as an instructional technique. The authors explain, "The study reported here is a pilot and is highly exploratory. It is a first step in developing a theory-based line of inquiry into desktop VR as an instructional technology with potential for Career and Technical Education" (p. 54).

Jeremy Ernst chose to focus upon the How to Assess It aspect in his article, Analysis of Cognitive and Performance Assessments in an Engineering/Technical Graphics Curriculum. "The purpose of this study was to evaluate cognitive and performance assessments using high school trade and industrial engineering/technical graphics student scores on a standardized post-assessment and a series of curriculum specified performance projects in the state of North Carolina" (p. 88).

Charles Backes and Janet Burns use their At Issue piece to look at the underlying foundation of the teaching/learning continuum in Career and Technical Education – what attracts and retains CTE teachers who enter through the non-traditional certification route? The authors state, “If the organization does not have a clear understanding of what motivates an individual to become a T&I or HSTE teacher, or what expectations the new teachers bring to their new workplace, is difficult to keep a teacher who feels rewarded and satisfied” (p. 106).

Enjoy!

Secondary Engineering Competencies: A Delphi Study of Engineering Faculty

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The acronym STEM (science, technology, engineering, and mathematics) has surfaced to prominence in both secondary and higher education. Of these four disciplines, only three are components of the nation's secondary educational system, science, technology, and mathematics. Engineering is only a post-secondary discipline. However, Kupa (1999) noted that using engineering as a framework can provide opportunities to engage secondary students in science, technology, and mathematics. McVearry (2003) stated the secondary schools are developing a favorable attitude towards engineering and that consequently more schools are attempting to infuse engineering into their K-12 curricula.

As secondary education disciplines, science, technology, and mathematics have K-12 learning standards developed and published by their respective professional societies. These standards include: *National science education standards,* (National Committee on Science Education Standards, 1999), *Standards for technological literacy: Content for the study of technology* (STL) (International Technology Education Association [ITEA], 2000), and *Principles and standards for school mathematics,* (National Council of Teachers of Mathematics, 1999). According to Thomas (2003) since engineering is not a recognized K-12 school discipline, engineering has been infused into current technology education programs with the support of the engineering and technology professions.

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The STL (ITEA, 2000) established both standards and benchmarks for core areas of K-12 technology education. Two of these standards for technology education are directly linked to engineering. STL Standard Nine stated that, "students will develop an understanding of engineering design" (ITEA, p. 99). In addition, STL Standard 10 indicated that "students will develop an understanding of the role troubleshooting, research and development, invention and innovation, and experimentation in problem solving" (ITEA, p. 106). Numerous other STL (ITEA) standards and benchmarks also indicate a strong relationship to engineering. Grimsley (2002) went on to note that "engineering content and concepts are intertwined in every aspect of the STL" (p. 1). "This is not surprising given that ITEA sought input from the National Academy of Engineering (NAE) on the standards, and later, submitted the standards to an intensive quality-review process at the National Research Council (NRC)" (Pearson, 2003, p. 1).

Since it appears that engineering is a component of K-12 technology education, are the competencies indicated in the STL (ITEA, 2000) the same competencies that the post-secondary engineering profession desires developed in its entering students? Or has the focus on STEM and its engineering component exposed a void in the current K-12 learning standards?

Purpose of the Study

The central purpose of this study was to expand upon previous research in relation to competencies that are desired by university engineering faculty in their incoming freshman. The results of this study should assist teachers in understanding what qualities and competencies high school students should possess upon entering into freshman engineering programs.

Research Questions

The following research questions were addressed by this study.

1. What competencies related to engineering do university engineering faculty indicate should be developed by high school students in a K-12 engineering/technology education class?
2. Are these identified engineering-related competencies already included in existing K-12 standards for science, technology, and/or mathematics?

Methodology

This study used a Delphi technique as noted by Paige, Dugger, and Wolansky (1996) and Wicklein (1993) to identify and analyze what secondary education competencies should be developed in a K-12 engineering program as indicated by engineering faculty. Similar to the rationale used by Scott, Washer, and Wright (2006), "the primary purpose for choosing the Delphi technique was to obtain a consensus of opinion from experts knowledgeable in engineering. The Delphi exhibited three distinct characteristics useful for this study: anonymity, interaction with controlled feedback, and statistical group response" (p. 46). According to Farmer (1995) using the Delphi technique is "the most appropriate method for attaining consensus in a national panel" (p. 2).

Both Farmer (1995) and Akers, Vaughn, and Haygood (2003) noted the first round should consist of open-ended data collection. Through open-ended listings, the participants in round one were instructed to identify the basic competencies that they foresee a secondary student needing to be successful in their college-level engineering or engineering technology program. Additionally, in round one Delphi panel members were asked via a cover letter and survey information section to provide demographic data; field of engineering, age, gender, highest degree earned, if they were a professional engineer (PE), years of industry experience, and years in higher education. The open-ended lists of competences were requested in four sections; engineering/technology related, mathematic related, science related, and other.

The Delphi panel for this study consisted of engineering and engineering technology professors from South Carolina State

University, Clemson University, Purdue University, plus Project Lead The Way (PLTW) affiliate professors. Faculty from Clemson University and Purdue University were selected because of the strong engineering and engineering technology programs at those land-grant institutions. South Carolina State University was selected based upon its engineering technology program and to insure faculty from underrepresented groups were included. These universities were additionally selected based upon the breath of the engineering and engineering technology programs, therefore insuring a wide range of engineering disciplines.

Scott, Washer, and Wright (2006) indicated that the section of panelists should insure “individuals actively engaged in the field” (p. 47). Therefore PLTW affiliate professors were selected based on their demonstrated commitment to infuse engineering competencies into secondary education. According to McVearry (2003), PLTW is the nation’s premier program in providing high schools with pre-engineering curriculum and linkage to college-level engineering and engineering technology programs. PLTW has grown from 11 high schools, mostly in upstate New York, in 1997 to a current total of over 1800 schools in 46 states, plus Great Britain (Hughes, 2006).

From this population of professors a group of 16 professors agreed to participate as the panel of this Delphi study. The panel covered a range of engineering fields including civil engineering (18.75%), electrical or computer engineering (18.75%), mechanical or industrial engineering (25.0%), plus professors of engineering technology (37.5%). Professors from research-intensive or land-grant universities comprised 43.75% (n = 7) of the panel, while professors from smaller state colleges, technical institutes, or community colleges comprised 56.25% (n = 9) of the panel. The demographic description of the first round panelists can be viewed in Table 1.

Table 1.

Demographic Descriptions of Delphi Panel

	N = 16	
Gender		
Female	1	(6.2%)
Male	15	(93.8%)
Age level		
40 years or less	2	(12.5%)
41 to 50 years of age	6	(37.5%)
Over 51 years of age	8	(50.0%)
Educational level		
Master’s	11	(68.8%)
PhD	5	(31.3%)
Years in higher education		
Less than 10 years	3	(18.8%)
11 to 15 years	3	(18.8%)
16 to 20 years	5	(31.3%)
Over 21 years	5	(31.3%)
Field of engineering		
Civil	3	(18.8%)
Electrical/Computer	3	(18.8%)
Mechanical/Industrial	4	(25.0%)
Engineering Technology	6	(37.5%)
Type of institution		
Research-intensive/ Land- grant	7	(43.8%)
State/Community College	9	(56.2%)

Round two of the Delphi survey for this study consisted of asking participants whether the competencies that emerged from round one should be included as a component of high school pre-engineering education. A four-point Likert-type scale was used for this rating, with 4 = strongly agree, 3 = agree, 2= disagree, and 1 = strongly disagree. Using the Likert-type scale was suggested for the second round of this type of study by Farmer (1999), Zargari (1996), and McCall (2001). McCall noted that “the words of the Likert scale are converted in meaningful way to an interval scale that gives the researcher the ability to use totals or to calculate numerical averages”

(p. 2). Nine of the panelist from round one participated in the second round survey of this study. This provided a response rate of 56.3%. The demographic characteristics of the second round panelists were consistent with the demographic characteristics of round one panelists.

Based on the results of the second round, competencies with a mean rating of less than 3.00 were eliminated from the list of competencies. These items were removed due to the fact that any rating under 3.00 would be classified as only “moderate”. In order to validate the secondary round findings, during the third round of the survey panelists were asked to give their professional opinion as to whether they agreed or disagreed that the competency was relevant for a high school pre-engineering program. Participants were given a list of the 41 competencies from round two and were then asked to indicate yes, if they believed the competency was relevant and should be a component of a high school program, or no, if they did not believe the competency was relevant and should not be a component of a high school pre-engineering program. Of the 41 competencies, 38 were confirmed by 75% of the panelists. These 38 competencies were deemed to represent the Delphi panel’s agreement of what competencies related to engineering university engineering faculty believe should be developed by high school students. The 38 competencies validated by these nine third round panelists provided the data for this study.

Findings

The Delphi panel participants noted three competencies at a mean of 3.89 (SD = 0.33). Those competencies included one from the mathematics-related area, one from the science-related list, and one from other-related competencies. In general, competencies associated with basic and interpersonal skills were rated higher than competencies with technical skills.

Table 2.

Engineering Competency Ratings

Competency	N	M	SD
Engineering/Technology			
Students should be able to perform deductive reasoning	9	3.44	0.73
Students should be able to sketch designs	9	3.33	0.50
Students should be able to operate fabrication equipment in a safe manner	9	3.33	0.50
Students should possess basic knowledge of engineering and the fields of engineering	9	3.22	0.44
Students should be able to apply the engineering design process	9	3.22	0.44
Students should be able to design solutions to engineering problems	9	3.11	0.33
Students should possess a basic knowledge of technology education	9	3.00	0.50
Students should be able to disassemble an object and analyze its components	9	3.00	0.50
Students should be able to perform basic 2-D mechanical drafting	9	3.00	0.71
Students should be able to apply geometric constraints	9	3.00	0.50
Students should possess basic electrical circuit theory	9	3.00	0.50

Table 2. (continued)

Mathematics			
Students should possess a high level of competency in algebra	9	3.89	0.33
Students should possess a high level of competency in trigonometry	9	3.78	0.44
Students should possess basic computation skills	9	3.78	0.44
Students should possess a high level of competency in geometry	9	3.67	0.50
Students should have graphing skills	9	3.67	0.50
Students should be able to perform basic statistics	9	3.22	0.44
Students should have exposure to calculus	9	3.11	0.33
Students should be able to perform basic Boolean mathematics	9	3.11	0.33

Table 2. (continued)

Science			
Students should be able to read meters, scales, and other instrumentation	9	3.89	0.33
Students should be able to relate science to mathematical concepts	9	3.78	0.44
Students should possess a high level of competency in physics	9	3.11	0.33

Other Related			
Students should be able to communicate effectively through writing (proper grammar)	9	3.89	0.33
Students should possess a high level of reading comprehension.	9	3.78	0.44
Students should demonstrate honesty	9	3.78	0.44
Students should possess a willingness to learn	9	3.78	0.44
Students should be open-minded to new concepts and ideas	9	3.78	0.44
Students should demonstrate problem solving skills	9	3.78	0.44
Students should be able to follow directions.	9	3.78	0.44

Table 2. (continued)

Students should be able to communicate effectively through speech (public speaking)	9	3.67	0.50
Students should demonstrate a strong work ethic.	9	3.67	0.50
Students should demonstrate effective interpersonal communication skills	9	3.56	0.53
Students should possess a high level of organizational skills	9	3.56	0.53
Students should be able to effectively communicate technical data	9	3.44	0.53
Students should possess a high level of computer literacy	9	3.44	0.53
Students should have a basic understanding of technical terminology	9	3.33	0.50
Students should understand aspects of group dynamics	9	3.22	0.44
Students should be able to perform basic research	9	3.00	0.53

The highest rated engineering/technology related competencies were the students' ability to sketch designs (M = 3.33, SD = 0.50) and the students' ability to operate fabrication equipment in a safe manner (M = 3.33, SD = 0.50.). The next highest rated engineering related competencies were the basic knowledge of engineering and the fields of engineering (M = 3.22, SD = 0.44) and the students' ability to apply the engineering/technology design process (M = 3.22, SD = 0.44).

Students possessing a high level of competency in algebra was the highest rated mathematic skill (M = 3.89, SD = 0.33). Processing a high level of competency in trigonometry and basic computation skills were the next highest rated mathematics skills (M = 3.78, SD = 0.44; M = 3.78, SD = 0.44). Students' ability to perform graphing and competency in geometry both rated at a mean of 3.67 (SD = 0.50). Participants also indicated that students should have "an exposure to calculus" before entering into post-secondary engineering/technology program of study. When asked to define "exposure to calculus" during the study's third round, participants provided the following responses: "1) introduction to integration and differentials - when possible supported with graphic modes - visualization software - applied theory to practice; 2) knowledge of integration and differentials; 3) to take simple derivatives and integrals; 4) a very introductory understanding of concepts of coordinate vs. slope with area when looking at graphs; and 5) practice thinking about the concept of value versus rate of change."

For the science-related competencies, a student's ability to read meters, scales, and other instruments was the highest rated science skill (M = 3.89, SD = 0.33). This was followed by a student's ability to relate science to mathematical concepts (M = 3.78, SD = 0.44). Possessing a high level of skill in physics was third on the science related competency ratings (M =3.11, SD = 0.33).

Table 2 also presents the mean ratings for the competencies that did not align with engineering/technology, mathematics, or science. Eleven of these other-related competencies were rated at a mean of 3.50 or higher. The highest rated of these non-technical competencies was the students' ability to communicate effectively through writing (M = 3.89, SD = 0.33). Next on the ratings were students possessing a high level of reading comprehension, demonstration of honesty, a willingness to learn, being open minded to new ideas, problem solving skills, and the ability to follow directions (M = 3.78, SD = 0.44). A student's ability to communicate effectively through speech and their demonstration of a strong work ethic were both rated at 3.67 (SD = 0.50).

Conclusions

The results of this study clearly indicate that, in general, university-level engineering and engineering technology professors rate students' interpersonal, communication, and work ethic competencies higher than engineering/technology, mathematics, or science-related skills. Rogers (1995) noted similar results noting that, "instructors perceived the affective domain competencies as more important benefits of technology education programs that competencies in the cognitive or psychomotor domains" (p. 68). These affective domain competencies and communication skills therefore need to be a vital component of the high school pre-engineering curricula.

This study's findings support the U.S Department of Labor (1999) report *Skills and tasks for jobs: A SCANS report for America 2000.* The U.S. Department of Labor noted foundations skills like responsibility, honesty, reading, problem-solving, and writing were essential for high school students to develop. This report divided the foundation skills into three skill-sets; basic skills, thinking skills, and personal skills. Table 3 indicates which US. Department of Labor foundation skill-set is represented by each of these identified other-related competencies.

Table 3.

Other Related Competencies and their Corresponding National K-12 Standards

Competency	Standard
Students should be able to communicate effectively through writing (proper grammar)	SCANS: *Foundation Basic Skills Writing*
Students should possess a high level of reading comprehension	SCANS: *Foundation Basic Skills Reading*
Students should demonstrate honesty	SCANS: *Foundation Personal Qualities Integrity/Honesty*
Students should possess a willingness to learn	SCANS: *Foundation Thinking Skills How to Learn*
Students should be open-minded to new concepts and ideas	SCANS: *Foundation Personal Qualities Sociability*
Students should demonstrate problem solving skills	STL: *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.* SCANS: *Foundation Thinking Skills Problem Solving*

Table 3. (continued)

Students should be able to follow directions	SCANS: *Foundation Basic Skills Listening*
Students should be able to communicate effectively through speech (public speaking)	SCANS: *Foundation Basic Skills Speaking*
Students should demonstrate a strong work ethic	SCANS: *Foundation Personal Qualities Responsibility*
Students should demonstrate effective interpersonal communication skills	SCANS: *Foundation Basic Skills Listening* SCANS: *Foundation Basic Skills Speaking*
Students should possess a high level of organizational skills	SCANS: *Foundation Personal Qualities Self Management*
Students should be able to effectively communicate technical data	SCANS: *Foundation Basic Skills Writing*
Students should possess a high level of computer literacy	STL: *Students will develop the abilities to use and maintain technological products and systems.* STL: *Students will develop an understanding of and be able to select and use information and communication technologies.*
Students should have a basic understanding of technical terminology	STL: *Students will develop an understanding of the core concepts of technology.*
Students should understand aspects of group dynamics	SCANS: *Foundation Personal Qualities Social*
Students should be able to perform basic research	SCANS: *Foundation Personal Qualities Reasoning* STL: *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.*

Competencies related to engineering and technology, as noted in Table 4, are all addressed by the current STL (ITEA, 2000). While the mathematics-related competencies noted by this Delphi panel and displayed in Table 5 are already incorporated in the *Principles and standards for school mathematics,* (National Council of Teachers of Mathematics, 1999) except for the panel's noting of exposure to calculus. All science-related competencies shown in Table 6 are currently included by The National Committee on Science Education Standards (1999) in the *National science education standards*.

Based on the results of this Delphi study of university-level engineering and engineering technology professors, there does not appear to be a need to suggest development of K-12 engineering standards. Engineering competencies related to K-12 education are already included in current mathematics, science, and technology education K-12 standards, plus the *Skills and tasks for jobs: A SCANS report for America 2000* (U.S Department of Labor, 1999).

Table 4.

Engineering/Technology Competencies and their Corresponding National K-12 Standards

Competency	Standards
Students should be able to sketch designs	STL*: Students will develop an understanding of the attributes of design.* STL*: Students will develop an understanding of engineering design.* NMS*: Representation Standard*
Students should be able to operate fabrication equipment in a safe manner	STL: *Students will develop the abilities to use and maintain technological products and systems.*
Students should possess basic knowledge of engineering and the fields of engineering	STL: *Students will develop and understanding of the relationships among technologies and the connections between technology and other fields of study.* STL: *Students will develop an understanding of engineering design.*

Table 4. (continued)

Students should be able to apply the engineering design process	STL: *Students will develop an understanding of engineering design.*
Students should be able to design solutions to engineering problems	STL: *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.*
Students should possess a basic knowledge of technology education	STL: *Students will develop an understanding of the characteristics and scope of technology.* STL: *Students will develop an understanding of the core concepts of technology.* STL: *Students will develop and understanding of the relationships among technologies and the connections between technology and other fields of study.*
Students should be able to disassemble an object and analyze its components	STL: *Students will develop an understanding of engineering design.* STL: *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.*
Students should be able to perform basic 2-D mechanical drafting	STL: *Students will develop an understanding of and be able to select and uses information and communication technologies.* STL: *Students will develop the abilities to apply the design process.* NMS: *Representation Standard*
Students should be able to apply geometric constraints	STL *Students will develop: an understanding of engineering design.* NMS: *Geometry Standard*

Table 4. (continued)

Students should be able to perform deductive reasoning	STL: *Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.* NMS*: Problem Solving Standard* SCANS: *Foundation Personal Qualities Reasoning*
Students should possess basic electrical circuit theory	STL: *Students will develop the abilities to use and maintain technological products and systems.* STL: *Students will develop an understanding of and be able to select and use energy and power technologies.*

Table 5.

Mathematics Competencies and their Corresponding National K-12 Standards

Competency	Standards
Students should possess a high level of competency in algebra	NMS: *Algebra Standard*
Students should possess a high level of competency in trigonometry	NMS: *Geometry Standard*
Students should possess basic computation skills	NMS: *Number & Operations Standard* SCANS: *Foundation Basic Skills Arithmetic/Mathematics*
Students should possess a high level of competency in geometry	NMS: *Geometry Standard*
Students should have graphing skills	NMS: *Representation Standard* NSS: *Content Standard A: Science as Inquiry* SCANS: *Foundation Thinking Skills Seeing Things in the Mind's Eye*
Students should be able to perform basic statistics	NMS: *Data Analysis & Probability Standard* NSS: *Content Standard A: Science as Inquiry*
Students should have exposure to calculus	
Students should be able to perform basic Boolean mathematics	NMS: *Algebra Standard* STL: *Students will develop an understanding of and be able to select and use information and communication technologies.*

Table 6.

Science Competencies and their Corresponding National K-12 Standards

Competency	Standards
Students should be able to read meters, scales, and other instrumentation	NSS: *Content Standard A: Science as Inquiry* NMS: *Measurement Standard* STL: *Students will develop the abilities to use and maintain technological products and systems*
Students should be able to relate science to mathematical concepts.	NSS: *Content Standard A: Science as Inquiry* NMS: *Connections Standard*
Students should be able to perform the scientific method in regard to research.	NSS: *Content Standard A: Science as Inquiry*
Students should possess a high level of competency in chemistry.	NSS: *Content Standard B: Physical Science*
Students should possess a high level of competency in biology.	NSS: *Content Standard C: Life Science*
Students should possess a high level of competency in physics.	NSS: *Content Standard B: Physical Science*

Implications for Technology Education

Even though new K-12 engineering standards are not suggested by the results of this study, technology teacher educators should examine the study's findings to insure identified competencies are included in their programs or their school's mathematics, science, and language arts curricula.

Engineering-related Competencies

Since it is clear that the engineering-related competencies are imbedded components of current technology education, these skills must remain as an essential component of the program. These skills included safe operation of fabrication equipment, knowledge of electrical theory, two-dimension mechanical drafting and sketching, plus engineering problem-solving.

Mathematics-related Competencies

Skills related to algebra, trigonometry, and geometry need to be integrated into secondary education courses where applicable. Graphing, statistics, and Boolean mathematics should also be incorporated into coursework. Courses in algebra, trigonometry, and geometry should be a component of technology education courses to better aid those individuals who wish to pursue degrees in engineering/technology. This study's findings did not support the inclusion of calculus into the secondary education classroom for those students pursuing post-secondary education in engineering or engineering technology.

Science-related Competencies

Engineering/technology education programs must insure that students are versed in the use of meters, scales, and other technical instruments. This could be incorporated into existing courses such as computer-integrated manufacturing, electronics, or any science course. Biology, chemistry, and physics are indicated by this Delphi panel for inclusion into the plan of study for those students who plan to pursue careers in engineering/technology. However, little preference was noted between these three science courses.

Engineering/technology education students should be required to relate science with mathematical concepts, especially during engineering/technology problem-solving activities. Engineering design and problem-solving activities should also stress the use of the scientific method.

Other-related Competencies

As noted by the U.S. Department of Labor (1999) and Rogers (1995) affective domain personal attributes must be a key component of any engineering/technology education program. Communication skills were also noted as an essential competency for high school graduates entering engineering or engineering technology programs. Secondary programs must require in their students competency in written communications, verbal communications, reading, honesty, strong work ethics, and a willingness to learn. These attributes cannot be sectioned into a course, but must be an essential and integrated expectation from day one through graduation and beyond.

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Preparing Technology Teachers to Teach Engineering Design

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Abstract

The purpose of this study was to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. This process was identified through a study of professional development activities that were organized and conducted by technology teacher education partner universities of the National Center for Engineering and Technology Education (NCETE) to prepare middle school and high school technology teachers to infuse engineering design, problem solving, content, and analytical skills into the K-12 curriculum. A collective multisite case study formed the methodology for this study. Data were collected using individual interview sessions that lasted 30-40 minutes, video materials, observations, and artifacts. A total of 15 interviews were individually analyzed, and then compared through a cross-case analysis. Several sub themes emerged to illuminate the central theme of professional development. These included planning, communities of practice, administration and climate, practitioner needs, activities in the classroom, expertise, meaning making, and assessment.

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Introduction

Global competition in the business world, the Internet, and widespread use of technology continue to create new challenges and opportunities for employers and workers. Gomez (2000) posited that the lack of technically-oriented individuals can result in significant labor shortages during such dynamic times. Preparing teachers who will be responsive to a rapidly changing workplace and the global economy as a whole has become a major challenge for technology teacher educators.

Future development of technology education curricula will be influenced by changes in the social, economic, political, and technological forces shaping each and every sector of our lives. Jobs in the 21st century, particularly those involving new technologies, will need team players, problem solvers, and people who are flexible and possess high levels of interaction skills. According to Leask (2001) these rapid technological changes illustrate the necessity for regular review of technology education curricula, and a need to constantly upgrade teachers' knowledge and skills. Teaching today involves a multifaceted work environment and demands continued professional development. What teachers teach and what they are prepared to teach should reflect the times in which they live if instruction is to be effective.

Previous research has reported the challenges of continuously preparing career and technical education teachers (Lynch, 1990, 1997; McCaslin & Parks, 2002; National Center for Career and Technical Education [NCCTE], 2001; Walter & Gray, 2002). A report on the status of career and technical education teacher preparation programs by the National Center for Career and Technical Education (2001) identified discrepancies between teacher preparation, practice, and professional development. Teachers often have too few opportunities to improve their knowledge and skills, and their professional development opportunities are of poor quality. The U.S. Department of Education (1998) acknowledged that professional development activities serve as the bridge between where prospective and experienced educators are now and where they will need to be in order to guide all students in achieving higher standards of learning and development.

Currently, the field of technology education stands at a critical juncture in its history. Clark (1989) postulated that technology education is in crisis, largely caused by the increasing changes that are occurring within society and technology. Ritz (1992) argued that there was much confusion in the field about what technology education was and what students in technology education programs should be learning. Israel (1992) identified the importance of developing a multifaceted curriculum that depicts the versatile nature and scope of technology education. Zuga (1999), Rowell (1999), and Cajas (2000) each stated that there is a great deal of research to be conducted in determining efficient and cost-effective ways to conduct professional development activities that would support teachers as they continuously improve capacity to help their students become technologically literate.

Today, it is imperative to identify curricular materials and instructional practices that effectively address technology education goals. Experts in the field of technology education have identified engineering as a profession that is closely associated with technology and strives to solve modern societal problems that have practical importance. This perspective places engineering as a field that is closely associated with technology education. The National Center for Engineering and Technology Education (NCETE) has proposed that the field of technology education adopt aspects of an interpretation of design based on the engineering definition. The center has advocated infusing engineering design as a focus for technology education curriculum (NCETE, 2005).

For technology education to successfully shift to a focus on engineering design, significant changes will be needed. Without these changes, the shift will simply be a relabeling rather than a substantial revision. Significant curricular and professional development is needed for a field of study to transition its focus to a new combination of instructional objectives.

Based on needs identified in the literature, this study investigated the content and instructional practices of teacher educators facilitating engineering design activities at selected NCETE sites.

The study also examined secondary technology teachers' reflections on their experiences with respect to content, delivery, strengths, and weaknesses of engineering design workshops at selected NCETE sites.

Purpose

The purpose of this study was to describe a process of preparing technology education teachers to teach engineering design concepts in the context of technology education. This process was identified through year long professional development workshops administered by teacher educators at two National Center for Engineering and Technology Education (NCETE) sites. The study identified and proposed recommendations for developing, implementing, and conducting professional development workshops for teacher educators who prepare technology education teachers to teach engineering design concepts within the context of secondary technology education.

The investigation was guided by the following research questions:

1. How are the two sites similar or different?
2. What factors influence teacher educators' choice of content and instructional activities when conducting engineering design professional development workshops?
3. What theories of instruction and learning do teacher educators use to teach engineering design in professional development workshops?
4. What influenced them to choose these theories?
5. How do teacher educators conducting professional development workshops plan to evaluate the effectiveness of the workshops in meeting stated objectives?
6. What reflections concerning their experiences with respect to content, delivery methods, strengths, and weaknesses of the engineering design workshops do secondary technology teachers have?
7. What are the strengths and limitations of each program?

8. What would secondary technology teachers like to have changed in engineering design professional development workshops with regard to content and instructional activities?
9. Why would they like the changes?
10. What implications for subsequent programs can be drawn from data collected at the two sites?

Method

This study assumed that, (a) knowledge is constructed through social interaction, (b) professional development workshop activities consist of a group of people with similar goals, insights and thoughts, and (c) professional development workshop activities assist in the development of a common approach to solve educational challenges among a group of people who share similar practices. Therefore, a qualitative case study approach was chosen to describe a process for preparing technology education teachers to teach engineering design concepts in the context of technology education. The case study approach was selected for several reasons. First, Merriam (1998) and Bogdan and Biklen (1998) postulated that case study research seeks to understand specific issues and problems of practice through a detailed examination of a specific group of people, a particular organization, or a selected activity. In this study, the researchers sought to examine faculty best practices and experiences of participating secondary technology teachers. Secondly, it was important that the researchers see and probe the content, instructional practices, and interactions that occurred between teacher educators and secondary technology teachers in the workshops. This approach to the study allowed the participants to relate their individual perspectives and experiences of engineering design professional workshop activities, as well as to describe their distinctive practices.

The social context of teacher preparation activities and learning influences the ways pre-service and in-service teachers construct new knowledge. Thus a social constructivist theoretical framework guided this multisite case study of two NCETE sites involved in teacher professional development activities. Teachers' interactions and participation in their communities' cultural and professional activities facilitate acquisition of new knowledge through practical experiences. Constructivist and communities of practice perspectives recognize individuals as active agents in the construction of their knowledge. Constructivism and communities of practice frameworks were chosen to guide the researchers as they interpreted participant's perceptions (Lavoie & Roth, 2001).

Participant Selection

Merriam (1998) stated that nonprobability sampling was the method of choice in qualitative case studies. For this study convenience sampling was used to select participants. Two reasons supported the decision to employ a convenience sample. First, the number of workshop participants at the study sites differed considerably since they were being offered over the summer. Second, workshop scheduling and administration of the programs were being conducted at different locations and by different personnel. It was important to coordinate with personnel at these sites to select study participants. Participants included secondary technology teachers and educators who participated in and completed engineering design professional development workshops during the summer of 2006 at two National Center Consortia Universities. Fifteen participants were interviewed. Two were females, and thirteen were male. Four of the participants were university professors whose area of specialization was teacher preparation in technology education and engineering design practices. The remaining eleven participants were middle and high school teachers, eight of whom taught at the high school level and the other three at the middle school level.

Data Collection

Data collection took place over the summer of 2006 at two NCETE centers and consisted of daylong observations, video footage of workshop participants completing design challenges, 30-40 minutes of interview session, and collection of artifacts. Interview transcripts were transcribed verbatim in October 2006 and sent out to workshop participants for member checks. The researchers divided the transcripts into two groups – workshop facilitators and workshop participants.

Data Analysis

Data analysis began with the first interview of each group as described by Miles and Huberman (1984) and Goetz and Preissle (1984). Each individual analysis was then followed by a cross-case examination of data as described by Merriam (1998). The researchers bracketed participants' responses by becoming aware of prejudices, viewpoints, and assumptions regarding professional development activities and teacher preparation. This helped them conduct the analysis from a fresh and open viewpoint without prejudgment or imposing meaning too soon. In other words, the researchers placed participants' stories in the foreground and moved their theoretical frameworks and biases to the background. Taking this position informed the researchers' understanding of participants' experiences without presupposing already held beliefs and characteristics of prior researcher experiences.

The 15 interviews were examined separately using some grounded theory strategies and inductive analysis. Each transcript was read with an open mind so that data could be approached without preconceptions about engineering design professional development activities in technology education and a general feeling could be developed regarding each participant's experiences. The researchers also spent several hours watching and replaying the video footage looking for data and instances that supported emerging themes. This process helped to identify expressions relevant to participants' experiences regarding professional development engineering activities, suggestions, and concerns as they tried to make meaning of emerging data. To keep on discovering anything new in the data and to gain a deeper understanding of concepts identified, Strauss and Corbin (1990) stated that researchers must conduct a detailed and discriminate type of analysis referred to as microanalysis. This form of analysis uses the procedures of comparative analysis, asking questions, and makes use of analytic tools to break data apart and dig beneath the surface.

The researchers grouped data which they found to have related meaning into categories, events, and interactions. Next, the researchers grouped and counted repetitive meaning units to eliminate redundancy. Hycner (1985) pointed out that it was important to note the actual number of times a unit of relevant meaning was listed since that might indicate some significance as to how important that particular experience was to the participants. This iterative procedure helped refine any initial categories identified, redefining them and fitting data into perceived categories. This process also facilitated comparison of data from interview transcripts within and from each site. Charmaz (2002) stated that after deciding which categories best explained what is happening in the study, grounded theorists treat these categories as concepts that serve to explain the phenomenon of interest.

Discussion and Findings

Participant responses and additional material collected during the study led the researchers to categorize data according to the commonalities and themes that emerged with no observed priority or order. Professional development emerged as a core theme and comprised the following sub themes: (a) planning, (b) communities of practice, (c) administration and learning environment, (d) practitioner needs, (e) activities in the classroom, (f) expertise, (g) meaning making, and (h) assessment. Figure 1 provides a visual organizer for these sub themes. Participants names have been changed to pseudonyms and quotes are used throughout this section to emphasize identified themes.

Figure 1. Components of professional development as described by participants of this study.

Professional Development

During the first two years the NCETE sought to increase the number and diversity of students who selected engineering, science, mathematics, and technology careers (NCETE, 2005). Teaming engineering faculty and technology educators in a synergistic approach to facilitate professional development sessions for secondary technology teachers based on testing, adaptation, and adoption of instructional techniques that enhanced science, technology, engineering, and mathematics (STEM) at the K-12 level was seen as a vehicle to accomplish this goal. According to Palinscar, Magnusson, Marano, Ford, and Brown (1998) professional development of teachers should result in improvement geared to their classroom practice, that is, planning, enactment, and reflection upon instruction for the purpose of helping students learn. Therefore, professional development is a means by which teachers acquire and enhance a set of skills and knowledge in order to meet new challenges of guiding all students in achieving higher standards of learning and development.

In this study, professional development meant several things to the participants. First, it referred to providing teachers with an additional tool, or improving some form of expertise they already possessed, to enable them to be more effective and efficient in performing their work-related duties in the face of change. Joe remarked, “It’s finding a new way to do something to hopefully be more effective in the classroom with students.” Kim stated that, “professional development is something that allowed an individual to extend their potential, it’s the thing that the lifelong learner will seek out as a professional.”

To most secondary technology teachers who participated in this study professional development referred to learning something new that would enhance what they were already doing in their classroom. With regard to the professional development workshop activity, Mike a middle school teacher, reported that the hands-on activities in the workshop were very important experiences for kids since they learned by seeing. Vin, a high school teacher, said, “I can use it with my students. I may not do it the same way in my class but I will definitely use it with my students."

Planning

As documented on the NCETE website, the organization used professional development as a vehicle to (a) develop secondary technology teachers' instructional decision making so that it focuses on the analytical nature of design and problem solving needed to deliver technological as well as engineering concepts, and (b) develop engineering analysis and design skills in technology teachers, strengthening their mathematics and science knowledge and skills.

Dillon-Peterson (1986) stated that effective long term change results most often in relation to an effective planning process rather than in relation to isolated miscellaneous short term activities. To achieve instructional changes of delivery of technology education material at the K-12 level, workshop facilitators strategically planned to conduct engineering professional development over a period of five years, with each year divided into three main workshop segments. The first segment was conducted during the spring semester, followed by a summer session, and the last portion happened during the fall and early winter. The planning component consisted of a formal system of doing things that realized a desired goal. Pete, a workshop facilitator who has been teaching for over thirty years, said, "You know, a lot of times you can make all sorts of excuses when things backfire, but if you had a plan you feel better prepared to enter into certain situations." According to Joe, a workshop facilitator, as soon as the summer segment is concluded workshop facilitators at Eleven University seek feedback on suggestions for improvement in readiness to plan for the next group of teachers. Joe stated:

> We will start thinking of what workshop activities we need to change and how, what materials they will need to order, what teachers will need to accomplish tasks presented to them, how many teachers will be invited to attend, and how many will be middle school or high school.

A plan can therefore, be thought of as a well devised guiding strategy that highlights procedures or a course of action that will lead to the realization of intended objectives. Figure 2 depicts a graphical representation of elements that go into planning an engineering design professional development workshop as identified in this study. These elements are not limiting and individuals should reflect and conduct a needs analysis before embarking on planning similar professional development workshops.

Communities of Practice

Communities of practice, a concept posited by Wenger (1998), espouses that learning is explored through the intersection of community, social practice, meaning, and identity creation. Wenger (2004) described communities as groups of people who share a concern or a passion for something they do, and who interact regularly to learn how to do it better. In this study, a group of teachers and workshop facilitators who shared a common goal met and participated in engineering design workshops.

Harif, a high school teacher who had been teaching for 15 years, thought the workshop provided an opportunity to sit and talk with other teachers about different ideas regarding how they could implement different projects in their classrooms. This is what Harif said:

> Even though, we may get away from the concept of engineering design, one is still learning. You’re learning what was successful in your class, what wasn’t. He may tell me something that was successful in his class, and I may take that to my class next year. So, we share ideas, because the bottom line is we’re all in here for one general purpose, the kids. What can we do to help each other out to all get to that common goal?

Pete, one of the workshop facilitators, summed up the idea of communities of practice when he said:

> By the time we get to year 4, we are going to have more seasoned people giving advice to people who are taking this for the first time. Also, because we're trying to focus on high schools that are planning on small learning communities.

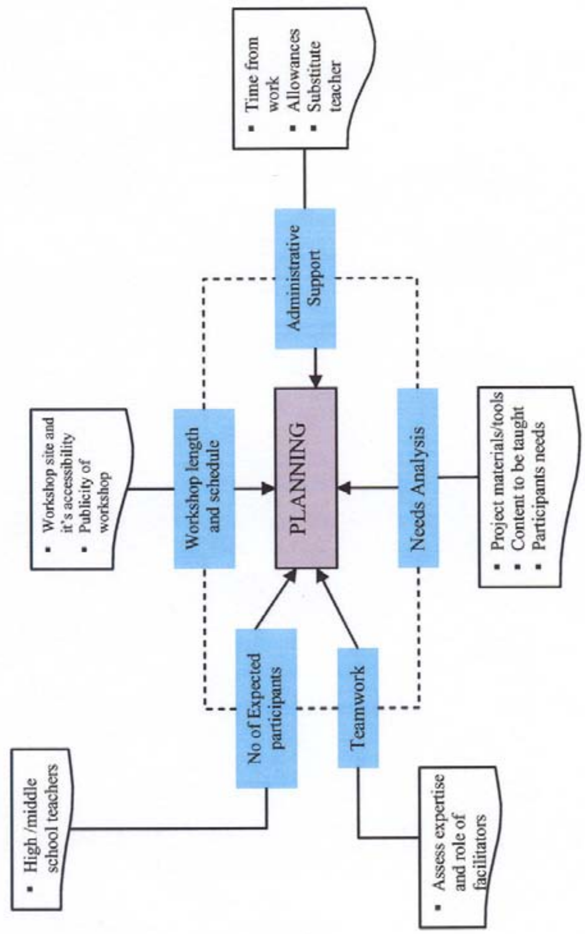

Figure 2. Elements of planning that embrace engineering design professional development workshops as identified in this study.

Such workshops present teachers with an opportunity to work together in teams, building coherent learning experiences for themselves and their students. As people work together to analyze what is working and to solve problems, they develop the ability to see how the whole and its parts interact with each other.

Administration and Learning Environment

Successful facilitation of professional development requires management of all the components that constitute its operation. Lockwood (1991) stated that administration and management of professional development programs called for expertise, effective planning, creation of a favorable learning environment, information flow between stakeholders, administrative support from the school system, feedback from the workshop facilitators, and regular opportunities to discuss ideas, experiences, and encountered problems.

In this study, the two sites had similar managerial styles and operations. Joe said that his team realized that they had their limitations and did not have all the answers, neither did they try to figure out all possible solutions to activities they had prepared before conducting the workshops. He stated that his colleagues were committed to supporting the participants and offered guidance to facilitate learning. This is what he said, "We left it to them to build the models, and we are here for support if they get too far off. We are learning quite a bit also at the same time."

On the other hand participants in this study unanimously agreed that the learning environment created by the workshop facilitators benefitted the participants. Mike remarked:

> I really don't feel out of place, it's very relaxed and you can move around the shop. The tendency is that if you are comfortable in your environment you are freer to make good decisions and if you feel out of place then you going to be pressured to make decisions.

The informal contextual learning environment created in these workshops, the support structure accorded by workshop facilitators in addition to time off from work, provided a setting in which participants negotiated meaning and socially-constructed knowledge as they sought to solve presented challenges while working in a team.

Practitioner Needs

Professional growth in education is considered to be a process of change in teachers' mental models, beliefs, and perceptions related to student's learning and cognitive abilities (Mevarech, 1995). Borko and Putnam (1995) stated that professional development programs that focus on expanding and elaborating teacher's knowledge systems are vital in today's climate of educational reform.

Lind, a workshop facilitator, described some activities his team conducted to meet this objective. He mentioned that they invited key speakers, took field trips, conducted group work, and participated in hands-on activities. Additionally he said, "We give them problems to work on individually. There are some homework assignments they take back and reflect on; we provide them with reading assignments so that they can learn more about the topics we do."

Pete stated that his main goal was to specifically teach workshop participants how to conduct engineering design challenges in their classroom. He also expected them to develop a plan for integrating these activities into their program. Joe echoed Pete's thoughts when he said, "we are not necessarily giving teachers new content, it's more about enhancing technology education lessons and putting in the engineering design."

When asked if the workshop had exposed him to strategies that he will use to transfer knowledge he had acquired in the workshop to his classroom setting, Myers, a high school teacher, said:

> I think that the workshop did try to focus on that issue, particularly in the second half of the workshop. They spent more time talking about what issues we will face in adapting this design challenge into our classroom curriculum. In my case, it fits very naturally into my robotics curriculum. But, for other people, it wasn't as close of a fit.

Barnes, a math high school teacher, had a different opinion. He remarked, "I knew everything already, so it was kind of…, I wouldn't say, a waste, but it was redundant." Contrary to Barnes's view, Myers commented that one of the things that the workshop did really well was making sure that teachers from a wide range of backgrounds were presented with all the knowledge they needed to participate before they embarked on the design challenge. He said, "We spent a lot of time working on background knowledge and information. While my background is engineering, I still enjoyed everything." The statements by Myers and Barnes, mirror Sayer (1996) statements that successful professional development programs should recognize the expression of differences in teachers' opinions, values, and feelings. Based on the expectations and suggestions of workshop participants, workshop planners need to conduct analysis and find how prospective participants were prepared to be teachers, their background knowledge, needs, and expectations of workshop material beforehand. Professional development for technology teachers that is geared to infusing engineering content in to the curriculum should be guided by a clear set of goals, mission, and planning.

Activities in the Classroom

Today, teachers seek professional development sessions that refine their conceptual and crafts skills, guide their teaching practices, and are related to daily classroom activities (Guskey & Huberman, 1995; Tallerico, 2005). Professional development activities designed to help teachers infuse aspects of engineering design into the K-12 level should be designed to promote team work and a state of engagement that will be rewarding to individuals. Brown, Collins, and Duguid (1989) argued that the activity in which knowledge is developed and deployed is not separable from learning and cognition. In other words, learning and cognition may be fundamentally situated in an activity.

In this study, instructions were sequentially ordered to provide participants with prerequisite knowledge to complete assigned challenges. Lind pointed to this when he said, "we give them all the requisite knowledge that they will need to know for the engineering design challenge that happens in the summer." Pete further espoused Lind's statement. He said:

> Because some of our teachers are from professions other than tech ed, it's a new exposure to things like project-based learning. The whole series of spring workshops is foundation laying. They come out of these sessions well-prepared to take on the engineering design challenge that we provide for them.

According to Block (1994), developing lessons that assist students to become better problem solvers should strive to (a) build students' commitment, (b) increase their engagement in difficult thinking processes, (c) develop their self-efficacy, (d) decrease their tendencies toward learned helplessness, (e) resolve their cognitive dissonance, and (f) increase their personal problem-space. This study identified that the key to infusing K-12 technology education curriculum with engineering content is developing classroom activities that reflect engineering design concepts while reflecting on Block's (1994) factors. These activities should be designed to consist of lectures, demonstrations, and hands-on activities that constitute the engineering design process, field trips to engineering schools, and motivational guest speakers. Additionally, teachers should seek to understand their students' learning styles as described by Kolb (1984).

Figure 3 depicts components that constitute infusion of engineering design activities in the classroom as described by participants of this study. Each of these components plays an integral role and should be taken into consideration when designing and implementing engineering design activities for the classroom.

Expertise

To be effective in incorporating aspects of engineering design into the K-12 curriculum, teachers must know the required subject matter so thoroughly that they can present it in a challenging, clear, and compelling way. Consequently, the nature of engineering design professional development workshops should help participants to develop expertise in terms of theory as well as practical application of knowledge and skills.

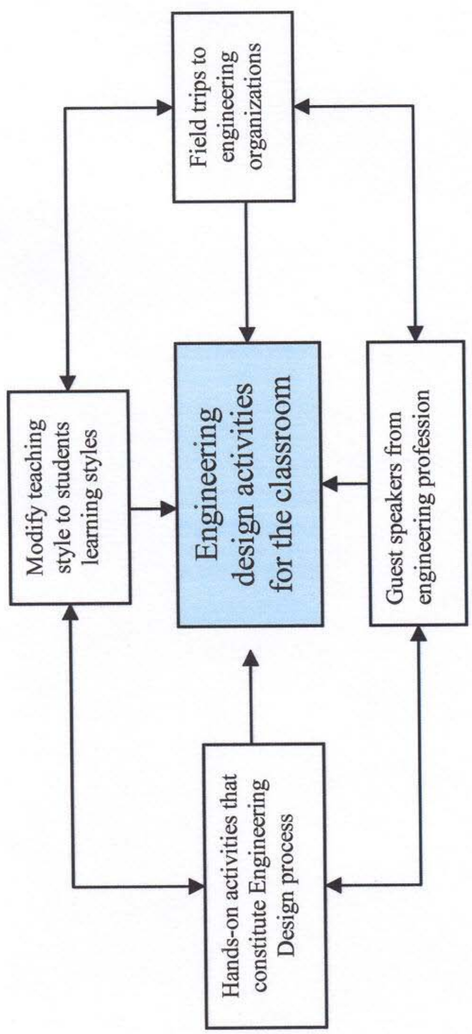

Figure 3. Elements that play a role toward implementation of engineering design activities in the classroom.

According to Berliner (1994) expert teachers know the cognitive abilities of the students they teach regularly. This gives them insight for determining the level at which to teach. In other words expert teachers use knowledge about their students' learning abilities and design lessons that connect ideas to students' experiences. They diagnose sources of problems in students' learning and how to identify strengths on which to develop and build a wide variety of learning opportunities for students, employing different learning styles. Thus an expert teacher is one who possesses some level of proficiency that enables them to create an environment that nurtures learning.

It was observed that participants in this study perceived workshop experiences as a basis for improving their teaching practices with regard to engineering design infusion into technology education. Virtually all participants of this study stated in one way or another that the workshop would benefit their students' knowledge base. Tim, a middle school teacher, commented, "I know right now by the end of the year I will have tweaked my projects enough to where I can take what my students are doing now and incorporate what I have learned here."

Mike stated:

> I think am going to take those rural kids and move them towards the high school faster and further and then knowing my counterpart at high school, knowing who he is and what he is doing, we both are going to say we going to have the best Tech Ed program in our county. I am able to go further and I know it's going to help my kids and that's the biggest part.

Meaning Making

To solve the design challenge presented, participants needed to make meaning of required tasks and negotiate among themselves probable solutions. In this study, meaning-making is portrayed when Mike, a workshop participant said, "Blake would come up and say we need to do this, but how? And I was like, am I going to fabricate it based upon what we have here?" Troy, a high school teacher, exclaimed, "I was the documentation manager and most of the time I was like wait a minute we have to get this done … okay we got that done, now we need to shift gears and get this piece done." These instances portray workshop participants negotiating thoughts as they made meaning of opinions presented in their teamwork activities to solve the design challenge.

Assessment

The last concept to emerge from the data was assessment. Assessing professional development and its impact is a long term goal which Joe termed as, "work in process and should be done on a continual basis." In this study, workshop facilitators at both sites agreed that they were not out to assess how successfully the participants mastered and completed the design challenge but how successful they implemented engineering design concepts into their curriculum and teaching.

Pete commented, "Yes, we do assess how well they master the design challenge. It's not significant. It's only done so that they have a sense of feedback. What we want is six teachers that can go out and touch 100 to 150 students a year."

Joe reported:

> We want them to experience some success with their projects and mentally get them to accept the value of engineering design and what it can bring to their classroom. It's opening them to do things in a new way, adding new things to the existing curriculum. If they do that and make a strategic effort to get the kids to do more predictive analysis, optimization, and try put that structure into their classroom, and we can go back in later and observe them exposing kids to these concepts, that is really what we are after.

This study therefore, portrays assessment procedures as a conduit that provides an opportunity for both workshop participants and facilitators to continuously improve, remedy professional development programs, and build upon the skills they have acquired and already possess to effectively and efficiently perform their teaching activities. In other words, assessment is envisioned as an incessant activity that seeks to challenge workshop participants to succeed in implementation of engineering design concepts in their classrooms and K-12 curriculum

How Results Address the Research Questions and Purpose of the Study

The findings revealed practical approaches to teaching engineering design to teachers and illuminated secondary teachers' and workshop facilitators' reflections and opinions. This understanding could enhance efforts to infuse engineering design as a focus for preparing technology education teachers and inform related classroom activities. Due to the nature of qualitative research design, these findings are not generalizable to a larger population and do not imply any priority with regard to the way they have been listed.

The following findings do summarize what the researchers learned from this study:

1. Professional development has different definitions.
2. Project-based learning is a powerful way to conduct engineering professional development workshop activities focused on infusion of engineering aspects into technology education.
3. To meet stated objectives, professional development requires commitment from facilitators and participants as well.
4. Professional development workshops that seek to infuse engineering design aspects into the K-12 technology education curriculum are enhanced when communities of practice and collaborative learning strategies are utilized.
5. Engineering professional development activities for secondary technology teachers is guided by the interplay of the following components: (a) successful planning, (b) a professional development administration and learning environment that exhibit communities of practice attributes, (c) meeting professional development needs and expectations of technology education teachers, (d) a set of activities that are transferable to the classroom setting and depict infusion of engineering design into technology education curriculum, (e) a feedback system, and (f) subject matter experts who exhibit expertise in administration and

facilitation of teacher preparation activities as well as engineering and technology disciplines.

6. Professional development engineering design activities situated in a contextual environment help students to be actively engaged and engender learning that is relevant to meaningful real world problems. Participants learn from each other and develop higher order thinking and problem solving skills as evidenced by the comments of respondents in this study.
7. Individuals undertake professional development for various personal and professional needs depending on where they are in their careers.
8. According to the participants of this study, engineering design activities meant for the classroom should seek to exhibit the following components: (a) hands-on activities that constitute engineering design processes, (b) field trips to engineering organizations, (c) engineering profession motivational speakers, and (d) modification of instructional practices and use of a wide variety of strategies that support student learning.
9. Figure 4 depicts a graphical representation of a process that can be undertaken to develop, administer, and evaluate professional development workshops that seek to infuse engineering design into the K-12 level technology education curriculum as described by the participants of this study. This process is not limiting and individuals may modify the steps to suit their needs. It is imperative that when performing each of the steps as described in the process, one needs to stop and reflect on the whole process upon finishing a given step. This process is not linear; rather it is broken into distinct structured steps or activities that call for careful planning, team work, and accessibility to vast resources. To interpret this process, start at the bolded rectangle and follow the direction of the arrows.

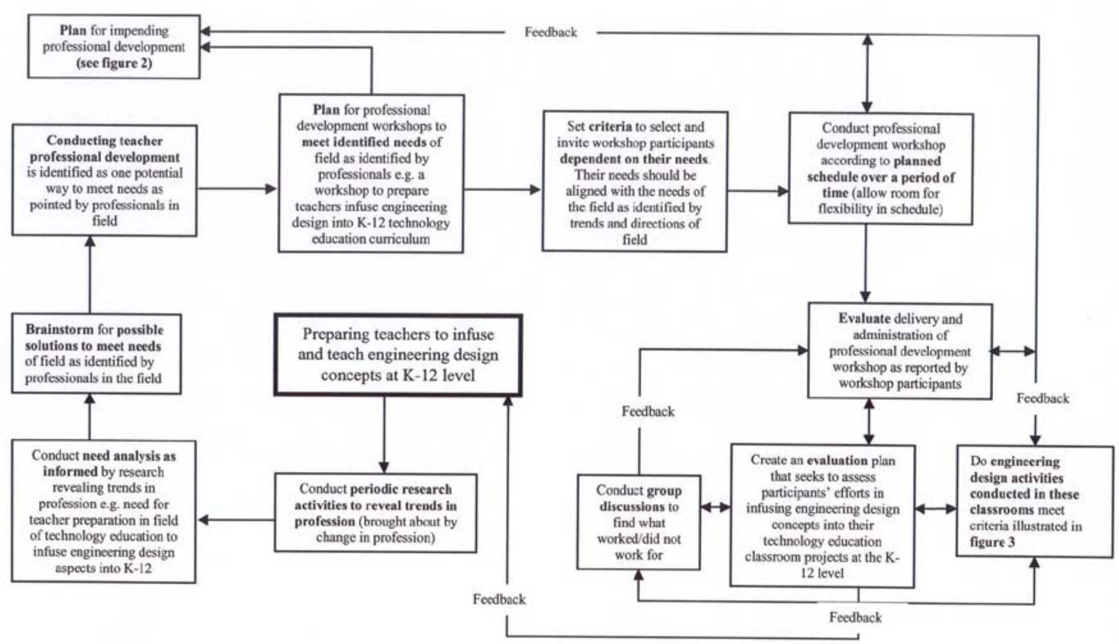

Figure 4. A process for preparing technology education teachers' to infuse aspects of engineering design into K-12 technology education curriculum as described by participants in this study.

Implications and Conclusions

Implications of this study apply to (a) teacher educators who prepare secondary teachers as well as prepare and deliver professional development workshops, and (b) middle and high school teachers interested in integrating engineering design into their classroom teaching

A major implication for practice will be the process identified for preparing technology education teachers to infuse aspects of engineering design into the K-12 technology education curriculum. This process is graphically presented and outlines ingredients and key components that teacher educators need to reflect on when designing professional development activities geared to infuse engineering design into the content of technology education. These components are not limiting in that they offer a reference point from which teacher educators can design similar workshops. Specifically this process requires educators to conduct periodic research activities that determine needs and the projected direction in the field of technology education in order to prepare programs that will continuously address impending changes. Built into this process should be reports on suggestions and feedback from workshop participants with reference to workshop content, teaching strategies, and general administration of the workshop.

This study calls for greater collaborative efforts among stakeholders in preparing in-service teachers who can infuse engineering design aspects into the K-12 curriculum. Such efforts are longitudinal in nature and need to be the cornerstone of technology education teacher preparation practices. These in-service education programs should be all-year round activities for teachers with evaluative practices in place. This means that procedures ought to be established to have teacher educators conduct in-service education at the state level throughout the year. To this end, school administrators should offer incentives and support structures for teachers who seek to attend workshops of this nature. Additionally, if infusion of engineering design at the K-12 level is the way forward for technology education, each state education department should seek to develop an organizational structure, personnel, and strategies that will support such an endeavor.

At the pre-service level, policy makers, engineering and technology education teacher educators, and administrators need to strategize, collaborate, and seek ways to develop and deliver programs that are interdisciplinary and that offer aspects of engineering design. Such programs should be designed to encourage the participation of students from engineering, math, science, and technology education. This venture will not only create broader rich learning experiences for these students but also meet the long term objective of infusing engineering design at the K-12 curriculum.

Nearly all teachers stated their reasons for attending the workshop; for example, one main reason these teachers indicated was that they liked the hands-on activities in the workshop and looked forward to incorporating engineering design aspects into their technology education classes. Having participated in the workshops, participant's experiences, suggestions, and practices might influence and offer middle and high school teachers a better understanding of the importance of engineering design and the significant role it can play when incorporated in the curriculum. The study also draws attention to characteristics of design challenges that seek to exhibit engineering design aspects in the K-12 classroom.

For infusion of engineering design to be successfully integrated in the K-12 level curriculum, there needs to be a systematic and yet flexible approach that includes the components identified in this study. Such an approach should be informed by policy makers, teacher educators, school administrators, and the wider community by actively supporting such ventures through participation in research studies that seek to find out more on how we can improve teacher preparation practices as well as curriculum materials.

Developing such practices not only emphasizes the concerns and research needs as reported by experts in the field of technology education, but also provides a foundation for innovative curricular changes. It is hoped that this study will help improve facilitation of engineering design activities and pave the way for future research that seeks to address infusion of engineering design at the K-12 level. Such a venture may bring about curriculum changes that offer broad learning experiences and are focused on using a systematic process to develop logical solutions within the constraints of the environment and society.

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Effects of Desktop Virtual Reality on Learner Performance and Confidence in Environment Mastery: Opening a Line of Inquiry

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Abstract

Virtual reality (VR) has demonstrated effectiveness as an instructional technology in many technical fields. However, VR research has generally lacked a sound theory base to provide explanatory or predictive strength. Further, research into the effectiveness of *new desktop technologies* that place VR within the reach of schools and teachers is currently embryonic. The study reported here is a pilot and is highly exploratory. It is a first step in developing a theory-based line of inquiry into desktop VR as an instructional technology with potential for Career and Technical Education. Grounded in several theory and research strands, this study compared the effects of presenting a complex scene via desktop VR and a set of still photographic images. The two treatments were given to groups drawn from the general population with equal representation by both genders and two age groups. Two performance measures and a confidence measure were analyzed using 2-way ANOVAs. Statistically significant main effects for treatment were found for all three measures, all in favor of the VR

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treatment. These findings were consistent with predictions based on the study's theory base. Several main effects for age and gender, and trends for interactions of age and gender with treatment, were also identified that may provide impetus for further research.

Introduction and Background

> *The use of visual technologies for teaching and learning in industrial education has produced dramatic extensions of the once traditional lectures, demonstrations, and hands-on experiences….visual technologies have enhanced the preparation of workforce specialists and technicians by bringing into classrooms and laboratories a breadth and depth of realism that has enhanced comprehension, increased learning performance, and reduced training time. Occasionally, however, there arrives a training technology that causes a realization that "this changes everything." Such a technology is virtual reality (VR).* (Ausburn & Ausburn, 2004, p. 33)

The term *virtual reality* (VR) has undergone continuous definitional changes since its introduction in the late 1960s as immersive experiences with computer generated imagery via head-mounted displays (HMDs). The term can now refer to a variety of computer-based experiences ranging from fully immersive environments with complex HMD gear, auditory input, voice activation, data gloves, and even body suits wired with biosensors for advanced sensory input and biofeedback, to new non-immersive desktop environments based on realistic PC imagery (Ausburn & Ausburn, 2004; Beier, 2004). However, in all its manifestations, VR is basically a way of simulating or replicating an environment three-dimensionally and giving the user a sense of "being there," taking control, and personally interacting with that environment with his/her own body (Arts and Humanities Data Services, 2002; Ausburn & Ausburn, 2004; Beier, 2004; Brown, 2001; Negroponte, 1995; Slater & Usoh, 1993).

In addition to simulating a three-dimensional (3D) environment, all forms of VR have in common computer input and control. An extensive review of VR research led the present authors to conclude that:

> It is generally agreed that the essence of VR lies in computer-generated 3D worlds. Its interface immerses participants in a 3D synthesized environment generated by one or more computers and allows them to act in real time within that environment by means of one or more control devices and involving one or more of their physical senses. (Ausburn & Ausburn, 2004, p. 34)

These characteristics of VR result in a stimulation of participants' senses that gives them a strong impression of actually being present in an environment with which they interact personally (Brown, 2001). Rigole (1996) summarized the characteristics that currently typify VR and defined it simply as any computer-generated simulation of a real or imagined 3-dimensional environment that is user interactive.

The newest form of VR is generally referred to as *non-immersive or desktop VR.* It is based on high-resolution panoramic imagery presented on a desktop computer and controlled by the user through simple navigation controls. Desktop VR is the simplest form of virtual reality and is quite different from technically difficult and costly immersive VR technologies that isolate users from the outside world and fully immerse them within a computer-generated environment through sophisticated devices such as head-mounted displays, data gloves, body suits, and complex visual display systems (Simpson, 2003). Several definitions have been offered that differentiate desktop VR from immersive VR. Simpson (2003) stated that desktop or non-immersive VR uses conventional desktop computers, multimedia, and distance learning systems. A recent online source defined desktop VR as 3D imagery that can be explored interactively at a personal computer by manipulating keys or the mouse so that the content moves and zooms in or out (WhatIs, 2005). The present authors explained that desktop VR employs mouse, joystick, or sensorball-controlled navigation through a 3D environment on a graphics monitor under computer control (Ausburn & Ausburn, 2004). Desktop VR is presented in the form of on-screen "movies" that are created by taking a series of digital still images and then using special VR software to “stitch and blend” these images into a single panoramic scene that the user can “enter” and explore interactively. The user employs a mouse or other navigation device to “…move and explore within a virtual environment on his/her computer screen as if actually moving within a place in the real world (Ausburn, Ausburn, Cooper, Kroutter, & Sammons, 2007, p. 9). Movement can include rotating the panoramic image to simulate physical movements of the body and head, and zooming in and out to simulate movements toward and away from objects or parts of the scene. Object movies can be embedded in panoramas to permit the user to “pick up,” rotate, and examine individual items, and clickable “hot spots” can interlink multiple panoramas and embedded objects. What characterizes these movies is that the user, “…chooses when and where to move and what actions to take, rather than being controlled by the pre-production decisions of a videographer” (Ausburn & Ausburn, 2004, p. 41).

A critical feature for educators of this new desktop VR technology is its technical and financial accessibility. In their discussion of the defining characteristics of desktop VR, Arts and Humanities Data Services (2002) asserted that desktop VR systems can be distributed easily via the Internet or on CD and that users need little skill to install them and only a standard computer with a simple software viewer to play and explore them. Creation of desktop VR movies requires a hardware/software investment of around $4000 plus a high-end off-the-shelf computer, and can be mastered by computer-literate instructors with a few days of training. It is this new form of desktop VR that is the focus of the study reported here.

Review of Literature

Perhaps because of its properties of user immersion and interaction, VR appears to be frequently effective as an instructional technology. Early in the VR research literature, Winn, Hoffman, Hollander, Osberg, Rose and Char (1997) claimed that three factors contribute to the capabilities and impacts of VR: (a) immersion, (b) interaction, and (c) engagement and motivation. Selwood, Mikropoulos, and Whitelock (2000) proposed that VR's power as an educational tool stems from its ability to exploit the intellectual, social, and emotional processes of learners. More recently, Seth and Smith (2004) asserted that the effectiveness of all types of VR comes from its ability to let learners experience a strong sense of presence in, and interaction with, a scene. They also attributed the success of VR technology to its ability to provide depth cues through stereo imagery that helps to convey to learners three-dimensional spatial relationships more realistically and accurately than conventional visualization tools. The accumulated research evidence indicates that enthusiasm for VR is generally high among educators and trainers who have tried it. An extensive review of the literature revealed several major themes that appear to have emerged in the study of instructional VR.

Concerns about Cost, Technical, and Instructional Design Challenges of VR in Instruction

Researchers have pointed out several areas of concern in using VR for teaching and learning. One important concern is the high levels of skill and cost required to develop and implement many VR systems (Mantovani, Gaggiolo, Castelnuova, & Riva, 2003; Riva, 2003). Concerns have also been raised about the as-yet unknown physical and psychological effects of VR (Mantovani, et al.; Riva) and the complexity of the high-end computing equipment it requires. For example, Riva (2003) and Sulbaran and Baker (2000) both discussed the "latency problem" in VR, which arises when inadequate computers or online band width dramatically limits the response time for navigation and interaction and destroys its usefulness as a reality simulation. Also cited as concerns for VR instruction have been weak instructional designs that: (a) fail to achieve adequate sense of reality and "presence" to allow VR training to transfer to the real world (Riva); (b) present a poor or incomplete analysis of a learning task (Wong, Ng, & Clark, 2000); or (c) have overly complex navigation control, poor guidance of learner exploration (Chen, Toh, & Ismail, 2005), unappealing look and feel

(Sulbaran & Baker), or poor simulation of concrete hands-on experience (Young, 2000).

Generally High Level of Enthusiasm and Research Support for VR as an Instructional Technology

Despite the concerns and issues for VR discussed in the literature, the general consensus of its effectiveness and benefits in teaching and learning has been extremely high (e.g., Ausburn & Ausburn, 2004; Boehle, 2005; Pantelidis, 1993; Riva, 2003; Selwood, Mikropoulos & Whitelock, 2000; Sulbaran & Baker, 2000; Watson, 2000). This apparent enthusiasm has been supported by considerable empirical evidence of the motivational properties and instructional benefits of VR (e.g., Mantovani et al., 2003; Pantelidis, 1993; Sulbaran & Baker, 2000; Winn et al., 1997). Watson's (2000) conclusion that "Most would consider that…[VR] systems provide strong potential…for the educational process," (p. 231) appears to represent well the general position and expectation of virtual reality researchers and users.

Training Success of VR in a Variety of Occupations and Industries

Published research literature documents many positive effects of VR. The field most actively reported in the VR literature is medical/dental education, where large numbers of published studies have attested to VR's benefits (Imber, Shapira, Gordon, Judes, & Mitzgar, 2003; Jaffe & Brown, 2000; Jeffries, Woolf, & Linde, 2003; Mantovani et al., 2003; Moorthy, Smith, Brown, Bann, & Darzi, 2003; Patel, Gallagher, Nicholson, & Cates, 2004; Riva, 2003; Seymour, et al., 2002; Urbankova & Lichtenthal, 2002; Wilhelm, Ogan, Roehaborn, Caddedder, & Pearle, 2002; Wong et al., 2000). Engineering education has also reported considerable success with virtual reality instruction (Sulbaran & Baker, 2000).

A variety of occupational and technical education programs have reported positive performance results in the research literature. These have included auto spray painting (Heckman & Joseph, 2003), firefighting (Government Technology, 2003), forestry machine operation (LaPoint & Roberts, 2000), meteorology (Gallus, 2003), and welding (Mavrikios, Karabatsou, Fragos, & Chryssolouris, 2006). Use of VR for both training and product development has also been reported in a variety of industries such as aerospace, petroleum, equipment design, vehicle prototyping, lathing and manufacturing, accident investigation and analysis, law enforcement, anti-terror response, hazard detection, crane driving, aircraft inspection and maintenance, and facilities planning (e.g., Flinn, 2005; Government Technology, 2003; Halden Virtual Reality Center, 2004; Jezernik, 2003; Sandia National Laboratories, 1999; Scavuzzo & Towbin, 1997; Sims, Jr., 2000; Shneiderman, 1993).

Research Focus on Immersive and Technically Complex VR Systems

In an extensive review of the literature on instructional VR, Ausburn and Ausburn (2004) reported that the published studies have focused almost exclusively on complex immersive VR technologies, with an absence of reported research on the instructional effects of new desktop VR technologies. While a few published studies have supported the effectiveness of desktop VR (Jeffries, Woolf, & Linde, 2003; Lapoint & Roberts, 2000; McConnas, MacKay & Pivik, 2002; Scavuzzo & Towbin, 1997; Seth & Smith, 2002; Wong et al., 2000), these are very small in number and as yet fall far short of establishing firm empirical support for instructional uses of desktop VR environments. These studies also fail to incorporate the recent technical improvements in digital cameras, software, and computer graphics that dramatically improve the realism, navigation, and immersion value of desktop VR. The lack of current research support for desktop VR is problematic because it is this new PC-based technology that brings VR within the reach of most schools and teachers, both technically and economically. The embryonic status of research on desktop VR, combined with its recent dramatic technical improvement and its instructional potential, provided the impetus for the study reported here and the line of inquiry arising from it.

Theoretical and Conceptual Framework for the Study

The theoretical underpinnings for this study are found in supplantation theory, Dale's Cone of Experience for media concreteness, Bandura's self-efficacy construct, and current research on technology-related age and gender differences. The study's conceptual frame is found in the Aptitude-Treatment Interaction (ATI) research models that emerged in instructional technology and design research of the 1970s to study interrelationships among learning task requirements, learner characteristics, and instructional treatment features.

Salomon's (1970) classic definition of *supplantation* identified this process as the explicit and overt performance or alteration of a learning task requirement that learners would otherwise have to perform covertly for themselves. The present authors have defined supplantation operationally in the context of design of technology-based instructional treatments as "…the use of an instructional treatment to either capitalize on learners' strengths or to help them overcome their weaknesses" (Ausburn & Ausburn, 2003, p. 3).

Supplantation-based instructional design is specifically based on an intersection or interaction of three critical components identified in the Cronbach and Snow (1977) Aptitude-Treatment Interaction (ATI) research model: a learning task with specific requirements, learners with specific capabilities/aptitudes related to the task, and an instructional treatment that bridges any existing gap between the two. At the psychological heart of supplantational instructional design is the notion that when learner characteristics are related to specific learning task requirements, an instructional treatment can be expected to have a positive effect on learner performance when it helps learners perform task requirements by "bridging" gaps between the task requirements and learner capabilities (Ausburn & Ausburn, 2003). This proposes that the process underlying the use of an instructional treatment that strengthens or completes the learner/task link through explicit performance of a learning task requirement will have positive impact on learning performance. This is the process identified in supplantation theory.

In a learning task requiring spatial orientation and memory for details in a complex scene, the task is made more difficult by the need to hold and manipulate *in memory* complex sets of visual details and relationships from image to image. Mental retention and manipulation of these visual components and their relationships are critical to learning performance when the task is presented via a sequence of individual still pictures, as is currently the standard technique in instructional graphics intended to introduce learners to a new environment. However, when the task is presented via desktop virtual reality, the mental imagery requirements are supplanted by the presentation medium. The VR presentation mirrors physical reality in which learners can see all visual components and their relationships simultaneously in a seamless environment and can move within the entire scene at will to examine visual details and relationships. In fact, the virtual reality goes beyond the physical one by giving learners a way to continue to explore and re-visit the environment indefinitely. In this study, application of supplantation analysis led the researchers to theorize that a desktop VR presentation of a complex visual scene would supplant for learners the difficult mental imagery processes required when the scene was presented via a series of still images, and thus lead to improved scenic comprehension. Because such a complex visual environment is frequently encountered in technical education, evidence supporting this supplantational capability of desktop VR could support its value as an instructional technology in CTE.

A second theoretical support for the predicted efficacy of VR in this study came from Dale’s Cone of Experience. This icon of instructional design theory, based in Piagetian psychology’s proposition of concrete versus abstract reasoning, proposed that (a) various types of learning experiences and media representations vary in their “concreteness,” (b) more concrete forms of experience and media are truer and more complete representations of reality, and (c) media representations that are more concrete can facilitate learning, particularly when reality is complex and unfamiliar to learners (Dale, 1954). Dale’s classic Cone of Experience presented various types of learning experiences in a pyramid with direct real-life experience at its base as the most concrete learning medium, verbal symbols (i.e., words) at its apex as the most abstract medium, and various other types of learning experiences and audio-visual representations arranged from base to apex in increasing abstractness as they move up the pyramid. The more completely and accurately an experience or representation presents "reality," the greater its level of "concreteness" in Dale's theory. One of the primary characteristics of VR is the fidelity of its presentation of the reality of a 3D environment and the relationships of items within the environment. Thus, application of Dale's Cone and the theory of media concreteness led the researchers to hypothesize that VR would provide a more accurate and realistic experience of a complex visual scene than would be possible with other forms of media representation and would add to the supplantation advantages of the medium. The combination of supplantation and experiential concreteness theoretical foundations led to a substantive theory for VR efficacy that could be called *supplantation-concreteness.*

This study was developed as an exploratory pilot to test the VR supplantation-concreteness hypothesis and to trial research procedural techniques in a *general* application with relevance in CTE before proceeding to tests in specific and more technically challenging CTE environments. The study also tested established general instructional design theories of supplantation and media concreteness in the context of the new desktop VR technology. Instructional design research history has demonstrated repeatedly that generalized theoretical concepts do not always apply predictably to new technologies with unknown characteristics and must therefore be thoroughly tested.

The study also incorporated in its design possible relationships of two other variables with desktop VR: (a) effects of VR on learners' perceived confidence in mastery of a complex visual environment, and (b) potential performance differences related to age and gender.

Theoretical support for inclusion of learners' perceived confidence as a dependent variable in the study is provided by Bandura's (1997) construct of self-efficacy, which he defined as belief or confidence in one's ability to take appropriate actions to successfully perform a certain task. Bandura asserted that one's level of self-efficacy, regardless of its truth, could impact actual performance. In this study, it was hypothesized that the supplantation-concreteness properties of VR might increase the technology self-efficacy of learners, thus increasing their perceptions of confidence and mastery as well as their learning performance.

Support for the inclusion of age and gender as intervening independent variables in this study came from several lines of research on digital technologies. Studies of the relationship of age and technology have established the deeply-ingrained technological skills and confidence of the digital natives of Generation Y and the Millenials, born after 1980, compared to those of the digital immigrants of earlier generations (Howe & Strauss, 2001; Prensky, 2001; Tapscott, 1998). Research has also shown a specific relationship of gender to virtual technologies. Twenty-five years of history with paper-and-pencil tests (e.g., Bennett, Seashore, & Wesman, 1973) have revealed consistent gender differences in skill in mental rotation of objects, with females generally having more difficulty than men. Evidence suggests that this gender gap in mental rotational skills is exaggerated in virtual environments, and that men and women often perceive virtual experiences quite differently, with men preferring more interactive environments than women (Space, 2001; University of Washington, 2001). Findings such as these led to a speculation in the present study that VR might interact differently with the technology self-efficacy and the performance of learners of different ages and genders and provided a rationale for stratification of the sample on these variables.

Purpose and Hypotheses

The purpose of this study was to compare the effectiveness of desktop VR in presenting a complex scenic environment to presentation with traditional still color images, in the context of the supplantation design model. The study served as a pilot for a line of experimental inquiry into desktop VR grounded in theory-based instructional design. At issue was application and testing of established instructional design principles to a new technology with unknown characteristics and comparison with a graphic medium currently extensively used in CTE. Specifically, the study addressed three aspects of learning outcome by comparing scores of learners who received a desktop VR presentation of a complex scene with those who received a still imagery presentation of the same scene. Null hypotheses tested were:

1. Learners receiving a VR presentation of a complex scenic environment perform no differently on a test of scenic orientation than those receiving a still imagery presentation.
2. Learners receiving a VR presentation of a complex scenic environment perform no differently on a test of recall of scenic details than those receiving a still imagery presentation.
3. Learners receiving a VR presentation of a complex scenic environment report the same level of perceived confidence in scenic comprehension as those receiving a still imagery presentation.
4. There are no main or interaction effects for age and gender with VR and still image presentations.

Methodology

Research Design

Following procedures described below, the study used a quasi-experimental design to compare the instructional effectiveness of desktop VR and still color imagery in presenting a complex visual environment via standard PC computer. The research used a posttest-only design, with two levels of experimental treatment rather than a treatment/control configuration. This design lacks the random selection of subjects that define “true” experiments (Campbell & Stanley, 1963; Fraenkel & Wallen, 2006), but is frequently used of necessity in education research. While the subjects were not randomly selected, they were randomly assigned in clusters to receive either a VR or a still image presentation treatment, which strengthened the study’s design.

Convenience samples were used, with built-in controlled representation from both genders and two age groups. Groups of subjects were randomly assigned to receive VR or still image instructional treatments, resulting in a fully factorial design. The groups were given the experimental treatments, and their learning performances and confidence perceptions were compared with descriptive statistics and two-way analysis of variance.

Subjects and Sampling Method

The subjects were 80 adults solicited by members of the research team (instructors and students in a graduate course in advanced technology and research) from people in their sphere of influence who fit specific age and gender requirements. The sample was purposively stratified to include equal numbers of males (n = 40) and females (n = 40) and equal numbers of representatives of the 18-35 (n = 40) and the 36-60 (n = 40) age groups, with each member of the research team identifying and testing an equal number of subjects in each gender/age subgroup. No limitations or requirements were imposed for selecting subjects, except that they have the required gender and age characteristics. Researchers were randomly assigned to use either the VR or the still imagery treatment presentation for their chosen subjects, thus creating a random cluster assignment of subjects to treatments. The sampling and treatment groups are summarized in Table 1.

Table 1.

Subject Sub-Groups and Numbers for VR and Still Imagery Treatments (N = 80)

Gender/Age Groups	**VR Treatment**	**Still Images Treatment**
Males, age 18-35	n = 10	n = 10
Males, age 36-60	n = 10	n = 10
Females, age 18-35	n = 10	n = 10
Females, age 36-60	n = 10	n = 10
	n for Treatment = 40	n for Treatment = 40

The sampling procedure used, while frequently employed in quasi-experimental research designs, raises cautions about generalizing the findings of the study to CTE populations in education/training settings. However, this sampling design was felt to be adequate for the exploratory stature of the study and its preliminary test of the VR supplantation-concreteness hypothesis.

Learning Task Environment and Presentation Treatments

Selection of task environment. The scenic environment for this experiment was a house interior showing several interconnected rooms and a complex set of furniture and other decorative elements. This task environment was chosen because it satisfied several criteria needed in order to preserve the internal validity of the experiment. The following criteria were met by the house interior selected for the study:

1. No subject could have had prior exposure to this particular scene, giving each subject an equal baseline for the learning tasks and eliminating possible prior knowledge as a confounding variable.
2. The scene had sufficient number and complexity of details to discriminate among learner performances.
3. The scene was generic and non-technical, eliminating previous experiences and comfort with a technical environment by some subjects but not others as a confounding variable.

There were two other important considerations in selecting the task environment for this experiment. First, the chosen environment needed to provide a “clean” test of the supplantation-concreteness hypothesis. This necessitated an environment that was familiar to all participants and would require no labels, pop-ups, or other graphic identifiers of scenic components and details that would create a visually complex field. Such an environment field could add an element of visual field complexity that could interfere with the supplantional and concreteness properties of VR that were under analysis in this study. The house interior met this experimental control requirement, leaving possible interactions of supplantation-concreteness with other treatment variables for later studies. Second, the task environment for the study needed to have relevance to CTE and training in industry. The relevance of a house interior to training in real estate and advertising is obvious. However, more importantly, it is representative of a whole *class of environments* requiring mastery of locational relationships and assessment of details that are frequently encountered in CTE and industry training. Laboratories, production shops, equipment interiors, operating rooms, crime scenes, and construction sites all represent technical versions of the kind of environment represented generically by the house interior. This provides a link from the house environment used in this study to many conceptually similar CTE and workplace task applications.

Task presentation treatments. A desktop VR QuickTime® panorama movie (created with VRWorx® software) and a set of eight still color photographs of the house interior scene were produced to serve as the instructional treatments for the study. The same digital camera with the same lens was used for shooting both treatments, and identical visual information was present in both sets of materials. The still images made a static presentation of the components of the house scene. The VR movie allowed the user to control and explore the scene interactively by "walking" within it via horizontal and vertical panning, in/out zooming, and clickable hot spot navigation. Both treatments were presented via computer under learner control, which represents the way similar instructional treatments would be presented in actual instructional environments.

Two PowerPoint® presentations were developed, one to present each treatment. In the VR treatment, the VR panorama movie was accessed from within PowerPoint via an Action Button. In the still photo treatment, the eight still photographs were presented sequentially in a PowerPoint slide sequence, and then all eight were presented simultaneously as "thumbnails" on a single slide. The two PowerPoint presentations contained identical instructions to the subjects for completing the research task, which ensured uniformity of task presentation protocol across all researchers collecting data.

Learning Task Instrumentation

Operationalizing the performance variables of scenic orientation, recall of scenic details, and confidence level in scenic comprehension was challenging, as no guidance from any similar studies was found in the literature. The instruments developed for the study were pilot tested with representative subjects from the general population and refined based on their feedback to assure all items were clear and posed no problems with interpretation. Further work regarding instrument validity and reliability will be required as this line of inquiry progresses; however, the instruments were viewed as suitable for use in this exploratory study.

The task instrument completed by each subject comprised three sections designed to measure the aspects of learning performance and confidence perception of interest in the study. The first measure was identified as *scenic orientation.* This was operationalized as a 15-item multiple-choice test requiring subjects to mentally position or locate themselves within the scene and identify the location of designated objects in relation to their position. The performance measure was number of correct responses out of 15. A sample question is shown in Figure 1.

You are sitting on the sofa in the living room with a large window directly behind you. The entryway from the hall is located

A. Behind you
B. In front of you
C. To your left
D. To your right

Figure 1. *Example from 15-Item Multiple Choice Test of Scenic Orientation*

The second performance measure was identified as *recall of scenic details.* This was operationalized as the number of correct and non-duplicative items, excluding large pieces of furniture, found in the house scene that the subjects could recall and list within a time of one minute. The one-minute time limit was established through preliminary testing as appropriate for discriminating among learners on this task.

The third measure was identified as *perceived confidence level in scenic comprehension.* This was operationalized as the subjects' self-reported confidence in their understanding of the details of the scene and the accuracy of their test responses, using the following five-point Likert-type scale:

1 = Absolutely no confidence	4 = Good confidence
2 = A little confidence	5 = Absolute confidence
3 = Moderate confidence	

The confidence or self-efficacy variable was included as a corollary and alternative to learning performance in assessing the effects of VR, similar to what frequently occurred in early research on color in instructional treatments. In this early research, it was often demonstrated that while color had no measurable effect on learning performance, it positively impacted learner attention to, interest in, and satisfaction with the learning experience. The implication was that increased learner approval must have some motivational impact on learning and that learning gains could be demonstrated if the right measures could be found. The exploratory nature of the performance measures used in this study suggested that the addition of a confidence variable was beneficial in examining a fuller range of potential effects of VR and suggesting alternative avenues for assessing impacts on learning performance.

Procedures

Members of the research team were randomly assigned to use either the VR or the still imagery presentation treatment with their subjects. Using a standardized written research protocol to minimize differences in data collection and recording procedures, members of the team selected their own subjects within the designated gender and age groups. Subjects were tested individually in a familiar location (home, workplace, etc) of their choice. Each subject was given the assigned treatment presentation, shown how to operate it, allowed as much time as desired to study the presentation, and then asked to complete the multiple choice test, the timed detail recall activity, and the Likert-type scale confidence question. Once subjects had completed their study of their presentation and begun the testing process, they were not permitted to see the VR movie or still images again.

All data for each subject were recorded on a standardized data sheet. The data were then coded and entered into an SPSS file for statistical analysis. Analysis was performed using descriptive statistics and full-factorial univariate linear model for fixed-factor 2-way Analysis of Variance.

Findings

To analyze the data, descriptive statistics were first calculated for the various gender, age, and treatment groups on each of the three performance variables. These data are shown in Tables 2, 3 and 4.

Table 2.

Descriptive Data for Gender, Age, and Treatment Groups on Scenic Orientation Score (Number of Items Correctly Answered Out of 15)

Gender or Age Group	**Presentation Treatment**	**Mean**	**Std. Dev.**	***N***
Male	Still Images	9.05	2.39	20
Male	Virtual Reality	9.60	3.55	20
Male	Gender Total (Still + VR)	9.33	3.0	40
Female	Still Images	10.05	2.28	20
Female	Virtual Reality	12.30	2.23	20
Female	Gender Total (Still + VR)	11.18	2.50	40
18 – 35	Still Images	9.25	2.24	20
18 - 35	Virtual Reality	11.55	2.93	20
18 – 35	Age Total (Still + VR)	10.40	2.83	40
36 – 60	Still Images	9.85	2.50	20
36 – 60	Virtual Reality	10.35	3.47	20
36 – 60	Age Total (Still + VR)	10.25	2.90	40
	Treatment Total – Still Imagery	9.55	2.37	40
	Treatment Total – VR	10.95	3.23	40
	Treatment Total (Still + VR)	10.25	2.90	80

Table 3.

Descriptive Data for Gender, Age, and Treatment Groups on Recall of Scenic Details (Number of Correct Details Listed in 1 Minute)

Gender or Age Group	**Presentation Treatment**	**Mean**	**Std. Dev.**	***N***
Male	Still Images	4.80	1.85	20
Male	Virtual Reality	5.80	2.57	20
Male	Gender Total (Still + VR)	5.30	2.27	40
Female	Still Images	5.90	2.10	20
Female	Virtual Reality	8.35	4.45	20
Female	Gender Total (Still + VR)	7.13	3.65	40
18 – 35	Still Images	4.85	2.25	20
18 - 35	Virtual Reality	7.25	1.92	20
18 – 35	Age Total (Still + VR)	6.05	2.40	40
36 – 60	Still Images	5.85	1.69	20
36 – 60	Virtual Reality	6.90	5.11	20
36 – 60	Age Total (Still + VR)	6.38	3.79	40
	Treatment Total – Still Imagery	5.35	2.03	40
	Treatment Total – VR	7.08	3.81	40
	Treatment Total (Still + VR)	6.21	3.16	80

Table 4.

Descriptive Data for Gender, Age, and Treatment Groups on Perceived Confidence Level of Scenic Understanding (5 Point Scale)

Gender or Age Group	**Presentation Treatment**	**Mean**	**Std. Dev.**	***N***
Male	Still Images	3.05	.83	20
Male	Virtual Reality	3.30	1.08	20
Male	Gender Total (Still + VR)	3.18	.96	40
Female	Still Images	3.00	.86	20
Female	Virtual Reality	3.95	.89	20
Female	Gender Total (Still + VR)	3.48	.99	40
18 – 35	Still Images	3.00	.73	20
18 - 35	Virtual Reality	4.00	.65	20
18 – 35	Age Total (Still + VR)	3.50	.85	40
36 – 60	Still Images	3.05	.94	20
36 – 60	Virtual Reality	3.25	1.21	20
36 – 60	Age Total (Still + VR)	3.15	1.08	40
	Treatment Total – Still Imagery	3.03	.83	40
	Treatment Total – VR	3.63	1.03	40
	Treatment Total (Still + VR)	3.33	.98	80

Two separate sets of 2-way ANOVAs were then performed: one set for gender by instructional treatment on each of the three performance variables, and one set for age group by treatment on each of the three performance variables. Statistical significance was set at the .05 level; trend was identified as $p \leq .16$; effect size was measured with the eta squared statistic, with moderate effect size identified as $\eta^2 \geq .06$ (Green & Salkind, 2005). ANOVA data for the gender and age analyses are shown in Tables 5 and 6, respectively.

Table 5.

ANOVA Data: Gender x Instructional Treatment for All Dependent Variables

Performance Variable	**Source**	***df***	***F***	***p***	η^2
Scenic Orientation (Score on 15-item multiple choice test)					
	Gender	1	9.618	.003*	.112+
	Treatment	1	5.508	.022*	.068+
	Gender x Treat	1	2.030	.156**	.026
	Error	76			
	Total	79			
Recall of Details (Number recalled)					
	Gender	1	7.780	.007*	.093+
	Treatment	1	6.950	.010*	.084+
	Gender x Treat	1	1.228	.271	.016
	Error	76			
	Total	79			
Confidence (5-point scale)					
	Gender	1	2.134	.148**	.027
	Treatment	1	8.537	.005*	.101+
	Gender x Treat	1	2.905	.092**	.037
	Error	76			
	Total	79			

* Statistically significant $p \leq .05$
** Trend $.16 \leq p > .05$
\+ Moderate effect size

Table 6.

ANOVA Data: Age x Instructional Treatment for All Dependent Variables

Performance Variable	**Source**	***df***	***F***	***p***	**η^2**
Scenic Orientation (Score on 15-item multiple choice test)					
	Age	1	.226	.636	.003
	Treatment	1	4.918	.030*	.061+
	Age x Treat	1	2.032	.158**	.026
	Error	76			
	Total	79			
Recall of Details (Number recalled)					
	Age	1	.224	.637	.003
	Treatment	1	6.311	.014*	.077+
	Age x Treat	1	.966	.329	.013
	Error	76			
	Total	79			
Confidence (5-point scale)					
	Age	1	2.970	.089**	.038
	Treatment	1	8.727	.004*	.103+
	Age x Treat	1	3.879	.053**	.049
	Error	76			
	Total	79			

* Statistically significant $p \leq .05$
** Trend $.16 \leq p > .05$
\+ Moderate effect size

The statistical results allowed rejection of all four of the study's null hypotheses. Results favored VR over still image presentation on all three performance measures. In addition, several main effects for gender and age and several interactions between gender/treatment and age/treatment were observed.

On the scenic orientation variable, a significant ($p \leq .05$) main effect of moderate effect size ($\eta^2 \geq .06$) for treatment was found in favor of VR for both gender and age. Similarly, significant main effects of moderate effect size in favor of VR were also found for the recall of details measure for both gender and age, and for perceived confidence level for both gender and age.

Several other findings were of interest. Significant main effects of moderate effect size were found for gender, in favor of the females, for both scenic orientation and recall of details. A main effect trend ($.16 \leq p > .05$) for gender in favor of females was also observed on the confidence variable that may be of interest in further research. A main effect for age, in favor of the younger group, on confidence level approached significance ($p = .09$). Interactions on confidence level for both gender by treatment ($p = .09$) and age by treatment ($p = .06$) also approached significance. Both these interactions were ordinal in nature, with both groups benefiting from the VR treatment. In the gender by treatment interaction, the females had greater benefits from the VR than the males; in the age by treatment interaction, the younger group had greater benefits than the older group. Two additional ordinal interactions showed trends at levels ($.16 \leq p > .05$) that suggested they may be of interest in further research. These were interactions on the scenic orientation variable by both gender ($p = .16$), with females making the greatest gains under VR, and age ($p = .16$), with the younger group benefiting most from VR.

Discussion, Conclusions, and Recommendations

Limitations of the Study

This study was a pilot, and should be regarded as such. Decisions on how to design and present VR and still image treatments, what performance variables to measure and how to measure them, and protocols for interacting with subjects and collecting data were all exploratory in nature. Difficulties were encountered in all these operationalization factors that will need to be refined in future research on desktop VR. One major decision for further research will be whether the learning performance and confidence variables used in this study are appropriate tests of the effects of VR and what additional outcome variables should be addressed. A second major consideration must be the refining of the performance measurement instruments and establishment of their validity and reliability, weakness in which limited the validity of this pilot study. Another limitation of this pilot was that it used subjects from the general population and a treatment task and naturalistic presentation settings that were general rather than technical in nature. These limitations affecting the study's population and environmental external validity mean that direct transference of the results to a CTE population, training task, and classroom environment should not be made without further research.

Another limitation of the study was imposed by its use of a posttest-only design. Performance on the three dependent measures could have been influenced by prior skills and experiences of the subjects rather than by this exposure to VR. Additionally, without pretest measures as baselines, it was not possible to actually measure changes in learning performance or learner confidence under the treatment conditions or to verify that any improvements occurred from the VR treatment.

Conclusions and Implications

Despite its limitations, this study served several useful purposes, provided valuable methodological information to aid in the transference of desktop VR research to a CTE environment, and offered preliminary evidence of the value of desktop VR in a training task with implications for CTE. Several conclusions can be drawn from the study's findings. First, the study supported the efficacy of desktop VR for improving learner performance and confidence in mastering a complex scenic environment. This has implications for CTE, because such environments are frequently encountered in CTE programs (e.g., laboratories, operating rooms, interiors of complex equipment, workplace sites, etc.), and if VR can be shown to improve mastery of such *locational environments*, this would suggest that its use may be suitable for similar learning tasks in CTE programs. In this pilot study, VR did indeed result in better scenic orientation, recall of details, and learner confidence across genders and age groups than did a presentation based on conventional still images.

Second, this study supported the authors' supplantation-concreteness theory for predicting and explaining the effectiveness of VR. Based on supplantation (Ausburn & Ausburn, 2003; Salomon, 1970, 1972) and media concreteness theories (Dale, 1954), it was hypothesized that the VR presentation would provide a highly realistic or concrete representation of a visual environment and would overtly perform the complex image retention and manipulation required to master a detailed scenic environment. These properties of VR were predicted to result in improved mastery and feelings of confidence or technology self-efficacy (Bandura, 1997) by learners. The results of the study supported this supplantation-concreteness hypothesis, thus providing at least the beginnings of a theoretical rationale and framework for research on VR applications in CTE environments. While these results are encouraging, the generalizability of the supplantation-concreteness theory is far from established at this point. New studies by the authors are suggesting that the theory is not yet complete and that there are variables such as complexity in the VR visual field that can override the supplantation-concreteness benefits of VR and actually disadvantage the medium if not controlled.

Finally, the study's findings of gender and age differences in performance and confidence under VR and still image treatments, and particularly the possibility of interactions of the learner variables and treatments, suggested that the supplantational and concreteness effects of VR may not be uniform across all types of learners and that some of these interactions may be contrary to expectations. In this study, findings of greater confidence overall by the younger age group and greater gains by this group in both confidence and scenic orientation performance with VR appeared to support the documented strong technology self-efficacy of these technology-savvy digital natives (Howe & Strauss, 2001; Tapscott, 1998). The finding that the VR treatment also yielded slightly greater confidence in the older age group may suggest a benefit for VR for the less technologically efficacious digital immigrants that merits further investigation.

The study's findings on gender revealed some outcomes contrary to expectations. The superior performance of the females overall in scenic orientation and recall of details and their trend for greater confidence were unexpected based on a lengthy research history of stronger skills in mental spatial manipulation among males in both paper-and-paper and virtual environments (Space, 2001; University of Washington, 2001). An explanation of these unexpected gender findings may be suggested in the related findings of greater *gains* in both spatial orientation and perceived confidence levels by females than by males under the VR treatment. This raises the possibility that the greater supplantation benefits were felt by the group with the greater *need* for the supplantation effects. This interpretation of disordinal interactions has been frequently implicit in the aptitude-treatment-interaction research model (Cronbach & Snow, 1977; Salomon, 1972).

The interaction findings of this study suggest that in future research on the effects of desktop VR in CTE, simple main effects hypotheses for the benefits of VR should be replaced by the type of aptitude-treatment interaction (ATI) hypotheses advocated by Salomon (1972), Cronbach and Snow (1977), and the present authors (Ausburn & Ausburn, 2003) supporting supplantational instructional design. Of value may be the age and gender variables that showed potential in this study, and particularly learner variables that concern preferred styles and capabilities in cognitive processing. Although Chen, Toh, and Ismail (2005) found that VR with guided navigational tools benefited learners irrespective of their learning styles, supplantation theory suggests that there may be important interactions between VR instructional treatments and learner style characteristics, particularly when those characteristics are defined in terms of individual differences in how information is perceived and processed. These style differences were referred to in an extensive body of instructional design and psychology research as *cognitive styles* or *cognitive controls*, defined by Ausburn and Ausburn in an analysis of instructional design implications (1978) as "…psychological dimensions that represent consistencies in an individual's manner of acquiring and processing information" (p. 338). Many classic dimensions of cognitive style/control, such as field independence/field dependence (Witkin, 1950; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962); reflective/impulsive cognitive tempo and visual field processing (Kagan, Rosman, Day, Albert, & Phillips, 1964); flexible/constricted field control

(Santostefano & Paley, 1964); and visual/haptic perceptual types (Lowenfeld & Brittain, 1970) deal with methods and capabilities in perceiving and processing visual information. Cognitive processing weaknesses in visual field perception variables such as separation of figure from ground, accuracy and speed in visual scanning and details, visual distractibility, and processing of mental imagery, as defined by various dimensions of cognitive style, may be precisely what the supplantation capabilities of VR can ameliorate. Thus, may be through research applying supplantation theory and ATI hypotheses to VR instructional treatments and learners' cognitive style characteristics that a detailed understanding of the effects of desktop VR is eventually gained. As this understanding is currently lacking, its advancement could give CTE a leadership role in instructional design research on an important emerging learning technology.

Recommendations

Based on this exploratory study and on enthusiastic reception from CTE educators in demonstration presentations, a line of inquiry on the effects of desktop VR in technical instruction is recommended. These VR studies should be moved into specific CTE applications where mastery of locational orientation, relational placement of objects, and recall of details in complex scenic environments are critical. Based on supplantation theory and instructional design, VR studies should apply ATI designs, with attention to learner gender, age, cognitive style/information processing, and technology experience variables which may interact differentially with VR's supplantational capabilities. Depth and refinement might be added to experimental data by the addition of qualitative interviews with CTE instructors and students who are using VR treatments for teaching and learning. The opening of such a line of inquiry may lead to empirical demonstration of the benefits of new desktop VR technologies in CTE environments, an understanding of the tasks and learners for whom these technologies are most beneficial, and instructional design guidelines for effective CTE applications of VR at the desktop.

Ultimately, the critical test for desktop VR in CTE will be to compare its instructional effectiveness with that of first-hand learning experiences and to determine its usefulness in augmenting or replacing physical reality. The authors offer several recommendations to guide this line of research. First, we must learn how and when to use VR effectively. Training in many occupations requires mastery of environments that are expensive, complex, dangerous, or nearly impossible to conquer without significant risks to resources or personnel. For such situations, the efficacy of VR in the learning process would be highly beneficial for CTE. However, in the pursuit of this goal, it is critical to discover not merely *that* VR works, but *how, why,* and *when* it works, for it is only through this understanding that sound instructional design principles can elevate this new tool from unpredictable techno-trend to functional and reliable learning medium. Most new technologies have walked this path before, as discussed by Moore and Kearsley (2005) in their description of an anthropology approach to media research as travelers' stories reporting personal experiences with a new technology and how well it worked. Their warning is that despite sophisticated data analysis in such studies, they remain anecdotal and can do nothing more than "point the way for research that is more controlled and systematic and that might give results that could be generalized beyond the particular case" (2005, p. 239).

Controlled and systematic inquiry into the efficacy of desktop VR in CTE applications rests on two pillars: (a) grounding in theory, and (b) careful evidence accumulation. Research on this new technology should avoid the naïve and simplistic assumption that "established" instructional design theories and principles necessarily apply to new technologies or to all applications of any technology. A long history of instructional technology research has shown this to be false. The authors propose that desktop VR research in CTE must be predicated on gradual accumulation of a body of empirical evidence gained through small steps in theory-based controlled tests to establish the technology's suitability for specific CTE learning tasks, learners, and conditions. This study began this exploration by examining from a set of theoretical propositions some specific learning effects of desktop VR in a particular type of learning task commonly encountered in CTE, comparing it to the still imagery methodology that currently dominates CTE textbooks and visual instructional presentations.

Conclusion

Virtual reality (VR) technology has a record of enhancing learning performance that has been well documented in recent literature. Until recently, despite its documented instructional success, VR has had limited classroom applications because of technical complexity and very high associated costs. However, recently improved new desktop VR now offers access to this technology to classroom instructors and to students with off-the-shelf computing hardware and realistic technology skills. Desktop VR has intuitive appeal to learners who are part of what Turkle (1995) called a new *culture of simulation*, in which digital technologies make it possible to create, explore, and interact with real and hypothetical "worlds" in which people increasingly work and play. This new technology also has been shown to be an effective instructional tool in a small number of empirical studies. However, research on the effectiveness of desktop VR has as yet been minimal, and there has been no attempt to explore and explain its effects in terms of theoretical perspectives and models. In summary, research on desktop VR is still embryonic: little is yet known about *if and when* this new technology is effective, and nothing is known about *why.*

This study provided a first step in demonstrating positive instructional benefits of desktop VR in a specific type of learning task, within the context of a theoretical framework. The study was a pilot: small scale, highly exploratory, and constrained by limitations in both internal and external validity. However, its successful results have implications for CTE. The task environment used in the study is conceptually similar to many found in CTE, where mastery of locational orientation and comprehension of details in complex visual scenes are critical. The study also supported the potential of VR to aid the technology confidence or self-efficacy, and thus perhaps the motivation, of learners. Finally, the study was a first step in developing a theoretically-supported and interaction-based research model for discovering effective desktop VR instructional design through the view of VR as what Squire (2006) called "… *designed experiences,* in which participants learn through a grammar of *doing* and *being*" (p. 19). As an emerging instructional technology that has both wide application in CTE and as-yet very limited research exposure, desktop VR offers CTE an opportunity to assume a leadership research and instructional design role. To borrow a metaphor from the technology itself, the door is standing wide open; CTE needs only to click on the hotspot, step through, and discover what may be waiting on the other side.

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Analysis of Cognitive and Performance Assessments in an Engineering/Technical Graphics Curriculum

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Abstract

The purpose of this study was to evaluate cognitive and performance assessments using high school trade and industrial engineering/technical graphics student scores on a standardized post-assessment and a series of curriculum specified performance projects in the state of North Carolina. Paired performance and cognitive student achievement data were collected and examined uncovering variations, differences, and correlations between the two methods of assessment. Significant differences between North Carolina Engineering/Technical Graphics I cognitive and performance assessment results were identified. Further examination of the data provided evidence that the cognitive and performance assessment results tend to increase or decrease together. Potential refinement of state assessment procedures and the possibility for assimilation of assessment practices given the need for varied assessment for individual and school accountability are discussed.

Introduction

Recent state and national standards documents and other systematic initiatives have encouraged improvements in state curricula and teacher instruction. Along with transformation in educational practice and instruction, a change in assessment practices is also required (Firestone & Schorr, 2004). Kiker (2007) indicates

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that business and industry leaders, paired with school reform advocates, suggest that successful preparation for the workplace and further education requires more than traditional core academic knowledge but also performance-based demonstrations and applications of knowledge. This presents a need for the development of assessments that measure 21st century skills and aptitudes within students.

The purpose of assessment is to accredit knowledge and performance of students (Barrow, 2006). The role assessment plays in education has been expanded recently to gauge school quality. Student achievements on standardized tests have been progressively considered as principal indicators for school evaluation in the United States. “Most Americans believe students’ standardized test performances are the only legitimate indicator of a school’s instructional effectiveness” (Popham, 2005). Over recent years, extensive changes in student assessment practices have been proposed. Federal and state agencies have encouraged the use of assessment procedures that are reflective of actual professional situations while implementing standardized assessments for accountability purposes (Pell, 2006). Career and Technical Education (CTE) courses use performance-based measures that model work environments maximizing opportunities for applicable feedback.

CTE courses possess performance components that are fundamental in the measurement of skill-based technical proficiencies. Requiring students to directly demonstrate their abilities provides opportunities for the instructor to effectively assess competence (Bracey & Resnick, 1998). Reeves (1996) suggested that standardized cognitive means of measurement fail to capture a true indication of individual performance competency, demonstrating the inadequacy of cognitive assessments and promoting alternative assessments.

Attainment of curricular goals through instructional standards-based content culminating in marketable knowledge and skill is a desired outcome of CTE. However, standardized assessment measures provide uniform measurement across student populations. “It is important that schools be held accountable, and that their performance be evaluated based on how well they succeed in teaching their students the basic set of knowledge and skills which they will need to become productive members of society" (Petterway, 2006). The current school accountability measurement system leans heavily in favor of standardized assessment. A standardized test is any test that is administered, scored, and interpreted in a consistent, predetermined manner. Standardized tests are designed to make predictions about how a test taker will perform in a subsequent setting (Popham, 2005).

Popham (2005) reports that there are two commonly used forms of standardized tests--standardized achievement tests and standardized curricular tests. Nationally standardized achievement tests make use of a comparative measurement approach. The essential rationale of all such tests is to compare a student's score with the scores earned by a previous set of test takers. Standardized curricular tests have been developed for accountability at the state level to better assess students' mastery of approved skills and knowledge. There is no single standardized achievement assessment that embodies an inclusive mapping of the content for student and school achievement (Haladyna, Nolen, & Haas, 1991). It is not the intent of the developers and publishers of standardized educational tests to fully represent individual and school content attainment; it is merely one of many achievement indicators. Multiple indicators are better representative of achievement provided its complex nature.

A large number of items are organized into developmental acquisition or skill-based learning sequences in curriculum-based (criterion-referenced) instruments and referenced to programming guides or curricula. Since the early 1990s the North Carolina Department of Public Instruction has developed assessments for all curricula. Every high school course offered in the state of North Carolina in Career and Technical Education has a standardized curricular assessment. The assessment is twofold in that it consists of a cognitive segment and a performance segment. The cognitive assessment, a component of the Vocational Competency Achievement Tracking System (VoCATS), is composed of multiple-choice test items that are found in secure course test item banks. VoCATS is a competency-based, computer-supported system encompassing course planning for each program, lesson planning within each course area, and standardized assessment items for each course's content. The performance assessment is composed of prescriptive activities accompanied by rubrics that identify desirable elements of the performance artifacts and categorize the level of attainment. An investigation was launched to pursue performance assessment and its potential incorporation into the state accountability system by first analyzing the Engineering/Technical Graphics I curriculum.

The Engineering/Technical Graphics I course is one of the many course offerings under the Engineering Technologies pathway of Trade and Industrial Education in the state of North Carolina. This course introduces students to the use of graphic tools used to communicate and understand concepts in the areas of architecture, manufacturing, and engineering. Topics include problem-solving strategies, classical representation methods (i.e. sketching), geometric construction techniques, orthographic projection, and 3-D modeling. Skills in communication and problem-solving are reinforced in this course.

Engineering/Technical Graphics Team

An engineering/technical graphics team was assembled to develop test items for the Engineering/Technical Graphics I assessment. The engineering/technical graphics team consisted of six engineering/technical graphics teachers from around the state, a local university representative, three CTE directors from around the state, and two VoCATS coordinators to oversee the CTE assessment process. Previous rubrics from North Carolina engineering/technical graphics curriculum projects were gathered and student drawings were acquired at different levels of quality. The team made copies of the student work and assessed each drawing using the previous engineering/technical graphics rubrics. Upon comparison of the scoring, the team found that there was a high degree of dissimilarity. Individual interpretations of the rubrics were similar, but different scoring results were calculated. The issue was constantly revisited throughout the course of a year, and the rubrics were eventually refined to the point that there were only minor differences in scoring between evaluators. The refined rubrics were then brought to the engineering/technical graphics teachers at a statewide conference to further investigate the scoring consistency. Drawings were distributed to the teachers and were evaluated. The results noted that a strong degree of scoring inconsistency still existed for rubric-based evaluation of performance assessment. Without extensive training, the refined rubrics did not seem to be a viable solution to the scoring inconsistency between performance evaluators.

Meanwhile, the CTE division of the North Carolina Department of Public Instruction launched an initiative to evaluate performance assessment in all program areas. The issue of scoring inconsistency was revisited, and upon further investigation, it was concluded that the use of rubrics in performance assessments was not the problem, but instead the performance assignments were so vaguely written that they were difficult to evaluate even when provided with a standardized assessment instrument. Other notable findings were that there were too many performance assessments in each course given the time allotments. The curriculum design process was altered to account for these performance assessment results. The Engineering/Technical Graphics I curriculum was updated to reflect these developmental changes.

Methodology

Teachers across the state of North Carolina were contacted and teacher participants in the study were selected based on interest. Seven teacher participants were selected from six different North Carolina counties to make up the engineering/technical graphics assessment team. The Engineering/Technical Graphics I curriculum is standardized in the state of North Carolina. The teachers used the existing Engineering/Technical Graphics I curriculum rubric and selected performance activities. Four performance projects were identified in which students could participate. Each performance project represented 25 points (of 100) of the overall student performance score. The teachers used as their cognitive assessment the state end-of-course assessment developed and administered by the state of North Carolina. The state VoCATS assessments are secure; classroom teachers cannot access assessments prior to administering them to their students. The VoCATS evaluation is scored on a 100-point scale. The teachers scored the three performance assessments and submitted them to the North Carolina Department of Public Instruction. The CTE division of the North Carolina Department of Public Instruction collected and scored the cognitive assessment items identified from the North Carolina VoCATS database. The purpose of these paired evaluations was to identify relationships when comparing cognitive and performance scores in Engineering/Technical Graphics I. The data were used to evaluate the null hypothesis: There are no significant differences in the means of the engineering/technical graphics student participants' overall performance assessment scores and their VoCATS post-assessment scores.

Presentation and Discussion of Data

The Engineering/Technical Graphics I performance and cognitive (VoCATS) data was examined to uncover variations, differences, and correlations. A scatter plot, (see Figure 1) of VoCATS post-assessment scores and overall performance assessment scores was constructed to provide a visual representation of the array of student achievement for the 157 engineering/technical graphics student participants. The scatter plot of the data does not display a clear linear alignment but does exhibit a concentrated grouping with visibly higher scores on the performance assessments when compared to the VoCATS post assessment.

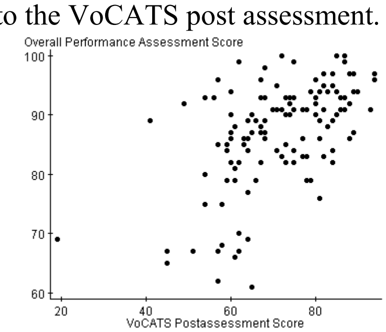

Figure 1. Scatter plot of Scores

The average of VoCATS post-assessment scores (71.77 of a possible 100) for the 157 engineering/technical graphics student participants is noticeably lower than the performance assessment scores (87 of a possible 100). The variance (149.15) and standard deviation (12.21) of VoCATS post-assessment scores are large in comparison to the variance (70.38) and standard deviation (8.39) of performance assessment scores indicating a larger spread of the engineering/technical graphics student participant scores on VoCATS post assessment. The standard error (0.97) of VoCATS post-assessment scores is greater than the standard error (0.67) of performance assessment scores uncovering a larger fluctuation in score values from participant to participant for the VoCATS post assessment. The medians of VoCATS and performance assessments exhibit minimal deviance from the means of VoCATS and performance assessments suggesting a somewhat symmetrical participant score distribution for both assessments. The range is calculated based on the minimum and maximum scores on the VoCATS and performance assessments. The sizable range (75) on VoCATS assessment in relation to the performance assessment range (39) reiterates the degree of difference in variability of engineering/technical graphics student participants between the two assessments (refer to Table 1).

Table 1.

Summary Statistics

Assess-ment	n	Mean	Variance	Std. Dev.	Std. Err.	Median	Range
Vo-CATS	157	71.7707	149.1522	12.21279	0.974687	72	75
Perfor-mance	157	87	70.38461	8.389554	0.669559	89	39

Figure 2 and Figure 3 represent the number of occurrences for VoCATS scores and performance scores for engineering/technical graphics student participants. Both histograms are skewed to the left indicating some upper limit; in this case, the upper limit is the maximum score of 100. A histogram representing a distribution is skewed if one of its tails is extended. A positive skew refers to a histogram that has a distinguishable tail in the positive direction and a negative skew has a distinguishable tail in the negative direction (Agresti & Finlay, 1997). Negative skewness is common in education where examinations are administered after a sequence of learning exercises. The VoCATS histogram exhibits a slightly greater skew than the performance histogram. The enlarged negative skewness of the VoCATS histogram is likely attributed to by the single engineering/technical graphics student participant score of 19 of 100.

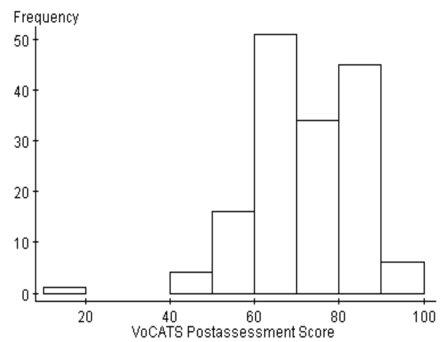

Figure 2. VoCATS Histogram

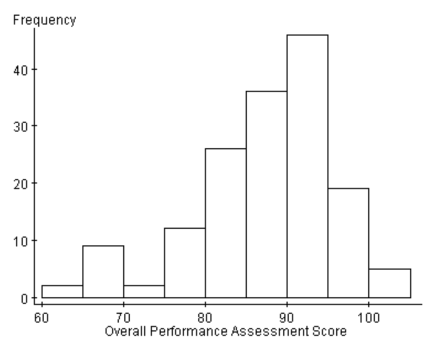

Figure 3. Performance Histogram

A hypothesis test was conducted given the clear differences in means and standard deviations of the engineering/technical graphics participant VoCATS and performance assessments indicated in Table 1. The Z-score was calculated using the following null hypothesis: There are no significant differences in means of the engineering/technical graphics student participants' overall performance assessment scores and their VoCATS post-assessment scores. Based on analysis of the Z-statistic (12.88) and the proportional value (<0.0001), the null hypothesis is rejected providing evidence that there is a significant difference between the means of the engineering/technical graphics student participants' overall performance assessment scores and their VoCATS post-assessment scores (refer to Table 2).

Table 2.

Hypothesis Test Results

VoCATS (n)	Performance (n)	Sample Mean	Std. Err.	Z-Stat	P-value
157	157	15.23	1.18	12.88	<0.0001

Table 3 offers an additional hypothesis test that was conducted based on the differences in variances of the engineering/technical graphics participant VoCATS and performance assessment scores indicated in Table 1. The F-statistic was calculated using the following null hypothesis: There are no significant differences in the variances of the engineering/technical graphics student participants' overall performance assessment scores and their VoCATS post-assessment scores. Based on analysis of the F-statistic (0.47) and the proportional value (<0.0001), the null hypothesis is rejected providing evidence that there is a significant difference between the means of the engineering/technical graphics student participants' overall performance assessment score variance and VoCATS post-assessment score variance.

A correlation coefficient was calculated (Table 3) between VoCATS and performance assessment scores to show how strongly the cognitive and performance assessments are related. Based on the correlation results (0.5633226) in Table 3, there is evidence that the two assessment scores tend to increase or decrease together, although not in a directly proportional manner.

Table 3.

Hypothesis Test Results

VoCATS (n)	Performance (n)	Sample Ratio	F-Stat	P-value	r
157	157	0.47	0.4	<0.0001	0.56

Conclusions

Decades of research and applied experience have honed the abilities of educational measurement practitioners to develop and implement a number of common assessment procedures (Williamson & Bauer, 2004). Even commonly used standardized testing measures with solid groundings and considerable histories must be constantly revisited. Through revisiting assessment pieces, cognitive or performance-based, measures are refined to more accurately gauge true student competence and ability. Based on significant differences between North Carolina Engineering/Technical Graphics I cognitive and performance assessment results, there is evidence to suggest that standardized assessments be used in conjunction with performance assessments to further provide evaluation of educational and professional standards in CTE. However, there is evidence that the two assessment scores tend to increase or decrease together. Upon further refinement of state assessment procedures, this finding and future findings like this can open the possibility for assimilation of assessment practices given the need for varied assessment for individual and school accountability. Until reliable assessments are developed for each course offering in CTE, existing state and national standardized assessments will continue to be relied on for school accountability and student exit requirements. Further development and implementation of performance-based assessments that require students to exhibit both skills and knowledge is imperative. More research in this area and other areas within CTE is necessary.

Assessment sends a message to students about the enduring concepts and applicable information that should be retained in order to succeed in a discipline. This brings about a new importance of assessment content. If both skill-based performance and cognitive knowledge measure are of equal importance in CTE, this should be reflected in assessment practice. Cognitive and performance assessment should be held in equal regard and should carry equal weight when considering curricular revisions and additions as well as assessment procedures.

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New Career-Technical Teachers—What Gets Them, and Why is it Important to Know?

Career Motivations of Trade and Industrial and Healthcare Science Second-Career Teachers

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Introduction

The road to finding a career path as a Trade and Industrial (T&I) or Healthcare Science (HSTE) (formerly Heath Occupations) teacher is winding at best. Job incumbents in this profession are hired after years of employment in an occupational field, and subsequently obtain the necessary credentials for their new teaching career (Burns, Schaefer, & Hayden, 2005). Various models of career motivation offer reasons why individuals choose a certain career and reasons why individuals may or may not be successful in a career choice (Lopes, 2006). Additionally, a variety of theories have been offered to explain career choices of people in general, for those in helping careers and for those in career and technical education (Harms & Knoblock, 2005). While these models and theories have great value to any discussion on career development, they fall short when it comes to determining why individuals whose first career choice was to work in a trade or in healthcare make a career change into teaching, and what influences them to make that change. In fact, the career development of T&I and HSTE teachers is largely unknown and overlooked.

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This exploratory study surfaced from the researchers' experience as T&I and HSTE teacher educators, and a review of previous research and literature revealing a scarcity of available data about the reasons T&I and HSTE professionals choose to change careers and become teachers. Our primary purpose is to describe the career choice motivations of T&I and HSTE teachers. From a practical standpoint, we would like to provide insight for those in the school system who recruit teachers and those who have the goal to retain them. It is our belief that we must understand the career motivations of new T&I and HSTE teachers in order to provide better induction into the field, mentoring that matches needs and stronger retention.

"Recruitment" of T&I and HSTE Teachers

Over the past 15 years, while working with new T&I and HSTE teachers we've heard numerous stories about how they have been "recruited" to fill vacant teaching positions. School nurses have been moved into healthcare science classes. Certified technicians at the "bus barn" have been transferred into automotive technology instructor positions. Maintenance personnel have been persuaded to teach construction classes. And, at least one HVAC technician has even been lured from his duties on the roof of the school while making repairs to the air conditioning system in order to become the new industrial maintenance instructor.

From years of conversations with these teachers, we know anecdotally that they bring varying values and motivations to their initial teaching experience. We also know that they enter their classrooms and laboratories with high expectations for themselves and for their students. Yet, like teachers of other content areas, over the course of one year they begin questioning their abilities to be teachers, and also have declining confidence in the learning potential of their students (Harris and Associates, Inc., 1991). During the first three years of the teaching profession is when teachers are most likely to leave (Ingersol, 2001).

The context in which new T&I and HSTE incumbents begin their work as a teacher and their motivations shapes their view of the teaching profession. It seems reasonable to suggest individuals, such as T&I and HSTE teachers, with a set of job preference values similar to circumstances surrounding their actual work as a teacher will experience greater job satisfaction than those individuals for whom the relationship between personal values and realities is zero, or even worse, negative. Blumenfeld (1988) suggested that as the values of the individual differ from the values of an institution, the individual will leave the institution. Therefore, from the point(s) of view of the new teacher, it seems worthwhile to be aware of, have, and/or develop a list of job attribute preferences so as to enhance subsequent career satisfaction. Additionally, the knowledge of individual teacher values in juxtaposition with job realities might facilitate traditional school organization activities such as recruiting, selection, assimilation and professional development.

A Special Collaboration

The extraordinary need for training new T&I and HSTE teachers brought program coordinators from two universities together to explore options for filling this need. It readily became apparent that there was a larger issue than having "enough seats" in a class to fill certification needs. The discussion led us to questioning ourselves as to how we can support the new teachers so that they are successful in their work and retained in higher numbers.

We decided to explore and describe why the students in our programs were choosing teaching as a second-career. Additionally we wanted to discover what similarities and differences existed in their reasons. We also desired moving toward the possibility of developing an instrument for more sophisticated research.

A review of the literature revealed no instrument targeted to T&I and HSTE teachers in the area of motivation to enter teaching. To begin, the two T& I and HSTE educators conducted interviews with 20 T&I and HSTE teachers to obtain lists of reasons why they chose to become teachers. The interviews yielded 12 key areas, which we combined into 9 reasons. Some of the reasons were extrinsic, or relating to motivation reasons related to environment, and some were intrinsic or internal values.

We developed a simple questionnaire that asked respondents to, "check only one of the reasons listed below as the primary reason that made them decide to enter the teaching profession: advancement/prestige, health reasons, hours, love of subject matter, pay (including benefits), religious calling, secular (non religious) calling, security, working conditions, other (specify reason)." The questionnaire was field tested with 16 former graduates of one of the programs. Additional changes in wording were made to reflect the feedback provided by the field testers.

The Profile of the New Teachers

During the summers of 2004, 2005 and 2006, participants who attended the New Teacher Institutes for T&I and HSTE teachers at Georgia State University and Valdosta State University in Georgia were asked to anonymously complete the questionnaire on the first day of class.

Of the 125 (100%) new teachers who participated in the survey, 57% were in their previous primary vocation for 8 to 15 years, and 52% reported having been their previous vocation more than 21 years. Ages ranged from 21 to 58. The teachers came from a diverse assortment of careers including nursing, emergency response, automotive technology, graphic design, construction, cosmetology, culinary arts, television and video production, law enforcement, human resource management, photography, and drafting.

From the Point of View of the Teachers

While the questionnaire asked the respondents to choose one reason, and the researchers expected that the stated reasons would suffice based on the field test, the results indicated otherwise. All respondents had one or more reasons why they were transitioning from full-time, certified industry or health professionals to certified educational professionals. Many of the respondents to the questionnaire were able to provide a primary reason why they entered the teaching profession, but when they saw the "other" category, they listed reasons in addition to the primary reason. In fact, many listed multiple additional reasons. The reasons stated were sometimes related to each other, but often they were not related. Following is an overview of reasons cited for becoming teachers. We will review the list in order of selection preference.

Religious or Secular Calling

The most frequent reason given for entering the teaching profession is the belief that the new teacher was "called" into the teaching profession. Nineteen percent of the respondents reported that they felt a "religious calling" to the profession, while 12 percent reported a "non-religious or secular calling." Combined, this indicates that nearly a third, or 31 percent, of the respondents felt "led" into the profession. When interviewed, they reported the desire to impact students and schools on a meaningful and perhaps a spiritual level.

Hours

Thirty percent of respondents indicated a desire to spend more time with their families, especially their children. They mentioned better schedules and working hours, no more "shift work", less travel time between home and the workplace, and summers and holidays away from the workplace. Several wrote that they had spouses who are teachers, and that they were looking forward to having the same schedule as their spouse.

Pay and Benefits

The third reason most reported for career selection was pay and benefits. Twenty-eight percent of the respondents selected "pay and benefits" as the primary reason for entering the teaching profession. Several respondents crossed out "pay" and indicated that "benefits" were what motivated them to enter the teaching profession. This makes sense when one considers that often construction personnel, automotive technicians, and others in industry receive lucrative salaries, but do not receive retirement, insurance, and sick leave benefits at a level competitive with education.

Love of Subject Matter

A considerable number of respondents, 10 percent, indicated that the love of their profession whether nursing or culinary arts, made them want to share it with others. Several mentioned "giving trained professionals back to their community" or "positively affecting others to choose a good career." These respondents seem to have a desire to advance their previous occupation or profession.

Other

Nearly half of the respondents wrote a reason in the "Other," section of the questionnaire along with the reason they noted in the selection boxes. This required that they write in their reason for entering the profession. The "write-in" reason that was most frequently mentioned was a "personal love of teaching." Many of the respondents indicated that they had previous teaching experiences in industry, civic organizations, church organizations or other levels of academia. These respondents chose to combine their technical expertise with an opportunity to teach full time in a high school setting. Some of the other reasons that were written in are: enjoy working with young people, retirement from previous vocation, encouraged by others to apply for an open position, tired of performing manual labor, other family members are teachers, a new challenge, desiring support from a chain of command, the ability not to be "micro-managed", and always wanted to be a teacher.

What does this mean?

Why should administrators and educational organizations be concerned with the motivations of T&I and HSTE teachers entering the field? We believe this question is crucial when it comes to recruitment and even more critical when considering retention issues. The National Commission on Teaching and America's Future Report (Hunt, & Carroll, 2003), purports, "The conventional wisdom is that we lack enough good teachers. But, the conventional wisdom is wrong. The real school staffing problem is teacher retention" (p. 6).

We contend that the current condition of the teacher labor market, number of applicants in comparison with number of positions, lends itself to the school organization accommodating the teacher more than the teacher accommodating the school organization. If the organization does not have a clear understanding of what motivates an individual to become a T&I or HSTE teacher, or what expectations the new teachers bring to their new workplace, is difficult to keep a teacher who feels rewarded and satisfied. We suggest that this does not necessarily have to be an expensive proposition for the organization. We further suggest that school systems must consider ways to keep these new teachers in their positions, and not allow them to lose sight of why they entered in the first place. Let's take a look at some possible suggestions, based on our experience, which may provide answers to premature burnout and turnover of these new educators. Again, we have organized our suggestions according to most selected responses.

Calling, Religious and Secular

Since we found that 31 percent of new T&I and HSTE teachers come into the profession to make a difference in students' lives, we believe that opportunities must be provided that allow them to do so. The issue of whether they have a "divine calling" or a "secular calling" may not really matter. The fact is that they feel "called" to teaching should be recognized. We suggest that these teachers may feel rewarded by the opportunity to get involved in their students' lives beyond the classroom. Co-curricular, career-technical student organization (CTSO) advisor responsibilities may provide these opportunities. Advisors work in small groups with students, focusing on specific individual needs. They often get to meet and interact with the parents and families of the CTSO members. A special bond can be created between the advisor and the group of CTSO officers. Other opportunities to serve as advisors and mentors also exist through extracurricular activities such as academic clubs and organizations, and civic organizations. New teachers who enter the profession to "make a difference" must feel empowered and supported in their efforts to do so. They often welcome opportunities to serve on advisory boards, student support teams, and parent-student boards. If these teachers don't feel that they are truly making a difference, they will likely experience job dissatisfaction because of unmet expectations.

Hours

Changing careers and taking on a new role with new responsibilities requires a great deal of effort and time. Some new teachers enter the profession with an inaccurate perception of the amount of time that must be devoted to becoming an effective educator. Therefore, the organization should be sensitive to this issue and help new teachers become organized and efficient. Occupations and professions, other than teaching, incorporate levels of responsibilities. Unfortunately, beginning teachers are traditionally expected to assume all the same responsibilities as more experienced teachers, and are often assigned the most difficult and challenging students, those that their more experienced colleagues do not want to teach.

Arguably, teachers have more time away from their workplaces than many occupations and professions. Shifts at hospitals, automobile service centers, construction sites, restaurants, and other technical workplaces can be 12 hour days, and sometimes six or seven days a week. Shift work also brings irregular work hours and often having to work on holidays. Most regular school-based activities don't occur on weekends, and few schools require teachers to work on major holidays. Additionally, winter, fall, and spring breaks often add up to weeks of holiday time, far out-pacing most vacations or breaks given in industry.

However, since schedule can be a major attractant to many new, second-career teachers, we believe that it is critical that administrators not overload new teachers with extra responsibilities that take them away from their families and personal lives to the extent that they were better off in their previous careers. These extra responsibilities may include extended day or extended year assignments, club or extracurricular assignments or extensive participation in professional development activities that are conducted after school or on weekends. When extra duties are necessary, it may be a bonus to these individuals if involvement of family members is possible, as is often the case with conferences and many student organization events.

Pay and Benefits

While some second-career teachers enter the profession from previous jobs that had higher pay, others experience an increase in their pay. However, nearly one fourth of our respondents chose this as their main motivator, making this a key issue. Institutions have limited resources and need to be creative in this area. For job incumbents who enter teaching to make more money, extended-day grants and extended-year contracts may be critical to recruitment and retention. The opportunity to earn supplemental income gives the new teacher the chance to provide financially for his or her desired level of economic status, while providing the school district with a highly-skilled, trained employee. These teachers may receive the supplemental pay for teaching an extra class during the school day or for teaching in a night-school or community education program. Extended-year opportunities may provide the district with extra maintenance personnel, health professionals, coaches, or tutors, depending on the teacher's skills and knowledge. Some states use extended-day grants to reward the advisors of CTSO's.

New teachers may have difficulty meeting initial certification requirements if they do not have the money to pay for college classes or other alternative certification programs, and this can be a reason they leave teaching. Unfortunately, we have encountered more often than not that new teachers have not been informed by the hiring organization that they would need to become certified, and how much of their salary will go towards certification. Some teach until their provisional certification expires and then return to their previous career. We suggest more transparency in the hiring process so that the job incumbent can make an informed decision, as well as understand the need to plan for education expenses. While further education is a reasonable expectation when one chooses to make a career change, it should not come as a surprise to the new teacher after they have accepted a position. Some organizations offer to cover some or all of the expenses as an investment in their new employee.

Although teacher salaries have increased over the past decade, many reports point out that when adjusted for inflation teacher salaries still lag behind other similar professions. Furthermore, compensation for teachers over the last ten years increased at a far slower rate than salaries for other professionals (Education International, 2005). On another note, research by Johnson (1986) revealed that better pay and higher status may draw incumbents to the teaching profession, but those reasons most likely aren't sufficient to retain outstanding teachers. Her research found that the best teachers stay in teaching because of intrinsic awards. However, sometimes they may be forced to leave because of poor salary or working conditions (Johnson, 1986). With that all said, we believe it is important for school systems to know how to attract and keep T&I and HSTE teachers other than through compensation. Further, education institutions need more options for recognizing and enhancing the environment and maintaining the satisfaction of their teachers than to simply throw money at them.

Love of Subject Matter

Our respondents pointed out that many new T&I and HSTE teachers have a love and respect for their professions. They take pride in being healthcare workers, skilled technicians, or experienced members of a craft. Teaching allows them to make a career change without giving up the identity of being part of their original occupation or profession. These teachers are motivated to prepare others for that profession to provide for the future of the field. These teachers need to feel respected by others for their professions. We suggest that T&I and HSTE teachers be given more opportunity to collaborate with academic teachers in order to share their areas of expertise. Further, when T&I and HSTE teachers are segregated or placed in building locations that are undesirable, it is difficult to make a good impression on other employees of the school, or feel respected.

We also think it is extremely important that these teachers are provided with students who have the desire and aptitude to be successful in their programs. It is discouraging for a teacher to be given students who can't read or compute a simple fraction when the teacher is required to teach them how to take and chart vital signs or read a blueprint.

We suggest that it is important to allow these new teachers to keep their identities with their technical or health related profession through attendance at technically-related conferences and seminars. Some of these teachers will seek opportunities to occasionally return to the field through temporary assignments or “educators in industry” programs.

The opportunity to supervise work-based learning students may be attractive to these teachers as this would help keep them in touch with their first occupation or profession. These professionals will generally strive to keep their licensures and certifications up to date and they should be respected and recognized for doing so, even though it may not be a requirement to remain in the classroom.

Personal Love of Teaching

Many new, second-career teachers are motivated because they perceive that they love teaching. It doesn’t matter where or how they discovered this motivation; they know that it is real and teaching fulfills a personal need. It is not surprising to know that these teachers seek ways to make teaching and learning more enjoyable and effective. They strive for a sense of autonomy and challenge in their classrooms.

When interviewed, these teachers had the expectation of having the facility, tools, equipment and resources needed to do their job well. They desire a functional environment with a reasonable number of students. These teachers often have no desire for a reduced load. Ironically, they are sometimes looked down upon by their peers and administrators for not getting more involved with other school functions. It is important to keep in mind that these new teachers are not reluctant to get involved; they simply want to focus on the actual teaching-learning process.

Next Steps

The quest to find the reasons T&I and HSTE professionals choose to change careers and become teachers started as a conversation between two teacher educators. We wanted to describe the career choice motivations of T&I and HSTE teachers. Admittedly, we started quite simply. Since then, we have located an extensive study over a 30-year period in which approximately 57,000 job applicants ranked the importance of ten job attributes that they perceived makes a job good or bad, i.e., individual values. The instrument itself (Job Preference Blank) has an extensive background in a variety of non-academic and academic settings (Jurgensen, 1978). We would like to adapt this instrument for use with T&I and HSTE teachers. We believe the hierarchical, rank order nature of the instrument will give us better descriptive within group data. We would also collect data on other teacher groups for comparison.

Conclusion

New second-career teachers who enter the healthcare science and trade and industrial education classrooms have numerous reasons for being there. Most can't attribute their desires to enter the classroom to one reason, but they want to be successful teachers. Administrators also want them to be there and want them to be successful so that they will remain in the classroom. By considering the reasons why these professionals become teachers, school systems can provide the resources and assignments that may lead toward a more satisfied, productive T&I or HSTE educator who is more likely to stay in the classroom. By having satisfied, productive teachers in the classroom, students are the greatest beneficiaries. Isn't this what education is really all about?

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