Table of Contents

Volume XXXVIII, Number 1, Spring 2012

Historiography in Graduate Technology Teacher Education

Jim Flowers & Brian Hunt

Abstract

A proposal is made suggesting the inclusion of historiography (i.e., historical research and the writing of history) into graduate technology teacher education. In particular, a strategy is forwarded to have graduate students in technology teacher education, who are working at schools in different locations, conduct historical research and write histories describing how local inhabitants transmitted technical learning dating back to the earliest human inhabitants. There are potential benefits for the graduate students, the students they teach, and the field of technology teacher education. Collaboration among institutions is recommended. After arguing for the proposal, this article uses a personalized historical narrative approach to evoke a connection with the reader that is not possible with more impersonal approaches and thus illustrating some of the richness of historical techniques.

Keywords: Technology Teacher Education, Historiography, History Education

Historiography in Graduate Technology Teacher Education

It is common to see a course in the history of technology education at the graduate level. It is not common, however, for graduate students knowingly to engage in historiography, or original historical research and writing about their field. The purpose of this article is to suggest an active rather than passive approach to history in graduate-level technology teacher education. Students would engage in the uncovering of historical information, make original analyses of this history, and write an original historical account of formal and informal technical and technology education in their locality. The suggestion is not for students to look at the history of technology or technical artifacts, but for them to synthesize information and uncover new historical information about the local history of formal and informal education about technical content. In doing so, they may ask questions such as, "How did the first Native Americans in the area pass on knowledge of different technologies to future generations?" and "What effect did teaching industrial arts only to boys in the 1940s have on a girl's relationship with technology?"

This article takes two paths to make a case for the inclusion of historiography in graduate technology teacher education. The first is a rationale for the proposal grounded in the literature. The second part provides a brief personal narrative from the second author, followed by the first author's biographical account of the development of this idea, including an example of integrating historiography into a graduate course. This is not a case study, but a personal narrative, similar to an oral history. It is included in an attempt to illustrate the power this method can have in evoking a connection between the reader and the authors. This technique is not common in the academic literature of technology education, though it can offer a richness not seen with other techniques. Because the authors advocate that students uncover often first-hand historical accounts, it was fitting to use the personal narrative technique.

A Rationale for Historiography in Graduate Technology Teacher Education

Often technology educators laud their profession as a "hands-on" field where students learn by doing. However, regarding the study of history within technology education and technology teacher education, learning by doing does not seem to have been emphasized, as evidenced by the lack of literature on this subject. After all, those who learn about hundreds or thousands of years of history have themselves only been alive for a matter of decades, so is it appropriate to suggest that these students should actually "do history" by creating historical works rather than merely learning historical information and reading the historical analyses others have performed?

Galgano, Arndt, and Hyser (2008) suggested that history not be thought of as "a collection of facts about the past . . . it is an interpretation of the past based on the weight of the available evidence" (p. 1). Historiography can be thought of as the research and writing of an original work of history: "The process of critically examining and analyzing the records and survivals of the past is here called historical method. The imaginative reconstruction of the past from the data derived by that process is called historiography (the writing of history)" (Gottschalk, 1969, p. 48).

The study of history does not necessarily entail that students actually write history, or as might be said, that they actually "do history." However, Loewen (2010) suggested that "history comes alive when students do, rather than merely read, history" (p. 83). He spelled out some typical processes this entails:

> Doing history, broadly defined, means identifying a problem or topic, finding information, deciding what sources are credible for what pieces of information, coming to conclusions about the topic, developing a storyline, and marshaling the information on behalf of that storyline, while giving attention to information that may seem to contradict the argument. (p. 83)

Although historiography includes several techniques of investigative reporting, it also requires historical reasoning and making connections between what is uncovered and other events outside the narrow field of investigation.

When students study history, it might at first seem like a collection of names, dates, and events. However, just as Bloom's Taxonomy (Bloom, Mesia, & Krathwohl, 1964) of the cognitive domain includes six levels from knowledge to evaluation, the study of history can be an increasingly rigorous and rich undertaking. Fallace (2009) argued that historical knowledge includes not just an understanding of facts, but of how the facts were constructed; he suggested that "historiographical knowledge will allow teachers to provide a more accurate view of the epistemological value of history, and that teachers will pass this knowledge to their students" (p. 206). Even without asking students to engage in historiography, a sound study of history provides a rich atmosphere where students analyze and question what has been written about history. Engaging in original historiography goes far beyond this: it includes finding previously unsynthesized historical data and making the connections.

Does it make sense for students to write history? Shouldn't that be what learned historians do? If a technology education teacher is asked in any way to play the role of a social studies or history teacher, we can look to social studies teacher education for models to aid in the preparation of technology teachers. Hoefferle (2007) noted her initial reluctance to teach undergraduates historiography, but concluded from her experiences that "historiography can be relatively easy to teach and learn at the high school and undergraduate levels" (p. 42). She cited its value in terms of critical thinking. After teaching historiography to undergraduate preservice social studies teachers, Fallace (2009) noted, "the course was more successful at breaking down the 'compartmentalized thinking' between discipline and pedagogy [than at] closing the 'breach' between . . . preservice teachers and historians" (p. 210). In this case, the students were becoming history teachers, so they were practicing that about which they were teaching. Blaszak (2010) asked preservice teachers "to 'do' some history using only archival primary sources" (p. 438) and later had them consider the reasons different student authors took different paths. We advocate the use of historiography for graduate students in technology teacher education; Johnson (2005) concluded there are several advantages for using historiography in graduate education:

> It serves as a continuum connecting past, present, and future that links all aspects of the discipline. Second, historiography trains the student to think historically over broad spans of time—a tool that can then be applied in their other courses and in their own research. Third, it challenges students to link themes, trends, methodological approaches over the breadth of time to see cause and affect within the spectrum of historical writing. (p. 528)

Those situated within a field may find it difficult to address the history of that field objectively due to their personal biases, their inability to realize that their own experiences are not necessarily those of others, and their unwillingness to convey or even acknowledge historical information that may portray the field unfavorably. Instead of objectivity being the goal, it is possible to leverage the subjectivity of the student/author. Munslow (2010) held that history is not "exclusively or even primarily empirical in origin, because it is a representation, history is an art form that asserts, argues, suggests and represents from a position or standpoint rather than provide objective meaning" (p. 108). It could be that an author's professional and emotional connection to a field can lead to insights regarding the history of the field that might not have otherwise emerged. However, it is also possible for the historical researcher to allow subjectivity to add too much of the author to the historical account; Bailyn (1994) suggested that this particular anachronism is a universal problem in the writing of history: "All historians are involved in this question; namely, whether or not one's present views are read back into the past and, therefore, whether the past is distorted, foreshortened, and its distinctiveness lost" (p. 50).

Learning to Write History

A new historian in any field may attempt to learn the correct way to write about history. But rather than approaching this convergently and seeking a single correct method, we might instead suggest that the new historian use several techniques, approaches, and tones. As Commager (1965) asserted: "There is no formula for historical writing. There are no special techniques or special requirements, except the technique of writing clearly and the requirements of honesty and common sense" (p. 37). Although the writing of meaningful histories can take many forms, Commager (1965) identified some typical patterns for such writing: chronological, geographical, political, cultural, institutional, and biographical. If secondary students are asked to show how personal communication devices have evolved during their lifetime, they might use a chronological approach; if technology teacher education graduate students uncover the ties between the history of education about technology and its impacts on gender-role stereotypes, they are likely taking a cultural approach, at least in that part of their historical writing.

Historiography can also be taught by having students first contrast different historical accounts. DeRose (2009) put together an activity for his high school students that involved looking at American History textbooks written during the last 200 years. The students were asked to consider how different historical accounts were written in several textbooks from the time of the event until the present time. The students noted that most of the accounts were similar but all differed slightly with respect to the author. One area of more notable differentiation by the students was about U.S. President Harry S. Truman's firing of General Douglas MacArthur. In a textbook written shortly after the incident, the author was critical of Truman's decision; yet in later textbooks, authors favored Truman's decision. This is not to say that the writing of history should be affected by the proximity of the event but that views often change over time.

K-12 Education

We propose that historiography be included in graduate technology teacher education (as outlined near the end of this article.) However, one outcome of that inclusion may be a richer teaching approach that more readily integrates history and historical methods for K-12 technology education students because these teachers may have a greater understanding and appreciation of the methods used to research and write history. The integration of science, technology, engineering, and mathematics (STEM) has been at the forefront of literature in technology education of late. For example, all five articles in the most recent issue of The Journal of Technology Education (Vol. 23, No.1) address STEM education, even though this was not a themed issue. Technology education students also study science and mathematics, and the push to integrate meaningful grade-appropriate education from these areas abounds in the recently published curriculum and literature of the field. However, technology education students study more than the STEM disciplines (Flowers, 1998), and it is possible to integrate their other studies into a study of technology. In particular, they also study history.

The existence of one or more K-12 standards for students in history or social studies is not sufficient for justifying the need for technology education teachers, themselves, to meet that standard. However, this does provide support for a technology education curriculum that integrates those social studies standards. National standards for K-12 students in history (National Center for History in the Schools, 1996) include standards for historical thinking. Among these is Standard 4 for students in Grades 5-12: "The student conducts historical research" (p. 68). This standard is divided into the following expectations:

A. Formulate historical questions from encounters with historical documents, eyewitness accounts, letters, diaries, artifacts, photos, historical sites, art, architecture, and other records from the past.

B. Obtain historical data from a variety of sources, including: library and museum collections, historic sites, historical photos, journals, diaries, eyewitness accounts, newspapers, and the like; documentary films, oral testimony from living witnesses, censuses, tax records, city directories, statistical compilations, and economic indicators.

C. Interrogate historical data by uncovering the social, political, and economic context in which it is created; testing the data source for its credibility, authority, authenticity, internal consistency, and completeness; and detecting and evaluating bias, distortion, and propaganda by omission, suppression, or invention of facts.

D. Identify the gaps in the available records, marshal contextual knowledge and perspectives of the time and place in order to elaborate imaginatively upon the evidence, fill in the gaps deductively, and construct a sound historical interpretation.

E. Employ quantitative analysis in order to explore such topics as changes in family size and composition, migration patterns, wealth distribution, and changes in the economy.

F. Support interpretations with historical evidence in order to construct closely reasoned arguments rather than facile options. (p. 68)

In addition to these standards for history, the curriculum standards for high school social studies identified by the National Council for the Social Studies (1994) include the following:

> Social studies programs should include experiences that provide for the study of the ways human beings view themselves in and over time, so that the learner can: . . . systematically employ processes of critical historical inquiry to reconstruct and reinterpret the past, such as using a variety of sources and checking their credibility, validating and weight evidence for claims, and searching for causality. (p. 34)

The idea of asking secondary school students to write local histories is not new. Stevens (2001) recalled that when he began teaching history at a junior high school in 1978, there were many local histories of Rye, NH, that had been written by eighth graders. Stevens' text, which is a primer on teaching secondary students local historiography, including the writing of local history, could be a valuable source for graduate students faced with a local history task.

Technology education teachers can integrate history and social studies into their curriculum. This allows technology education teachers to leverage the learning and experiences students gained in working toward those standards in their social studies classes. In particular, a technology education teacher who has personally engaged in historical research and the writing of history would likely be better prepared to integrate content that supports these history and social studies standards and to address Standard 7 from the Standards of Technological Literacy (ITEA, 2007): "Students will develop an understanding of the influence of technology on history" (p. 79).

Pannabecker (1995) suggested that within the history of technology education, a narrative approach seems at odds with a systems approach, though he believed both are needed. Although a systems approach may, for example, show how successive cultures used different systems to achieve certain needs (or in this case, certain needs for technical education), a narrative approach might convey both the interconnectedness among forces in the environment and an emotional connection by people of a given time.

Could engaging in historiography influence a teacher's approach to his/her own content area? Possibly. Pannabecker (1995) contrasted internalist, externalist, and contextualist approaches to the history of technology (not technology education) in a way that has implications for technology education. Though the internalist, he claimed, would consider technological artifacts primarily in view of the history of the design of those artifacts (as in the evolution of the bicycle), externalists may see the artifact as a mere instance or example in the primary discussion of social and political change (e.g., the impacts on society). A contextualist might include both the elements of internal product design and complex and changing interactions with several factors of society. A graduate student who engages in a historiographic journey in the field of technology education may tend to have the more holistic contextualist approach because of the variety of information and connections that would be examined. It could be that information that was key to an alternative approach troubled a student so much, that, for example, it became impossible for the student to address the curriculum changes of the past adequately without trying to understand how the Great Depression and two world wars impacted that curriculum, and without considering how that curriculum influenced the local workforce and the quality of life for local inhabitants. A teacher who has faced such interconnected and confusing information in graduate education may well be apt to do more for her or his K-12 students than to end a design lesson with, "Oh, and brainstorm the impacts on society from this technology."

One of the aims of graduate education is to prepare researchers in a field. Petrina (1998) recorded that of the 96 examples of research methods in the first eight volumes of the Journal of Technology Education, there were six (5%) instances of "historical" and one instance of "methodological (historiography)" (p. 35). He concluded that "JTE comes across as a text where conservative voices are favored and critical voices are the exception" (Petrina, 1998, p. 51.) Of the 16 categories of research methods he used, it could be argued that those related to historical research may tend to favor conservative voices of older researchers over the voices of those who are younger. But in a field where more research and more critical voices are needed, it might be that an emphasis on historiographic methods in graduate technology teacher education could influence a change.

Our Journeys

Although it is not customary to include a biographical narrative showing the emergence of an author's idea, it seems informative in this instance, although it must be treated as anecdotal. After all, this account is actually the written history of the idea's development, that is, a biography illustrating a bit of micro-historiography to show how it may evoke a different relationship between the reader and the content.

A Student's First Step toward Historiography

As the coauthor of this article, I remembered an undergraduate perspectives course that examined how technology had influenced humans and how humans have affected technology. One assignment in that class stuck with me: it was to research the history of Thomas Midgley and make a stand on his behalf. I read previously written works and found conflicting stories about a great inventor, an environmental killer, a mastermind of two evils, and a great asset to two industries. I soon discovered the reason for the conflicting stories was the dates of the articles. Midgley discovered that Freon was a great refrigerant and that by adding tetraethyl lead to gasoline he could boost the octane of the fuel increasing performance and fuel efficiency. When these discoveries were initially made Midgley was a hero; later when the environmental and safety issues behind Freon and leaded gas were discovered, Midgley was no longer a hero. I think I remember this best because I had to dig and find the information on my own but moreover that I had to interpret and evaluate that data to make a stand on his behalf. Although most of my work was historical analysis, I believed I had found something new that was worth sharing with others. This was a first step toward historiography for me, and it was empowering. But it did not push me to see myself as a writer of history where I could actually add to our society's historical knowledge.

An Instructor's Journey

I have been involved with technology education and industrial arts for several decades. I found myself newly assigned to teach a longstanding, online, master's level course on the History and Philosophy of Technology Education. The graduate course was to be taught to those majoring in an online master's program in technology teacher education. This program appealed to working K-12 technology education teachers from across the United States who were place-bound and unable or unwilling to relocate to a university to pursue graduate studies. They are situated at schools and within communities in a variety of states in the USA.

With a background that included a degree in philosophy, I have never considered myself to be an insider in the field of technology teacher education, but one who is more apt to offer criticism. Our field has a rich history, with many notable figures and movements; frankly, I felt out of my league when I learned I had been assigned to this class. Both my lack of knowledge of the history of the field, and my difficulty in promoting any current school of thought, or "party line," as I called it, were problematic.

To prepare to teach this online graduate course, it made sense for me to consult many resources and to learn about the rich and varied history of the field, along with the different philosophical underpinnings. But I was still not willing to be a "sage on the stage" and to base the course content largely on my knowledge of these areas. I didn't feel authentic in providing direct instruction that mirrored, say, the "This We Believe" document (ITEEA, n.d.), where a creed of the field is forwarded. Slogans such as "Technology for All Americans," "Technology Education, The New Basic," and even "Project Lead The Way," seemed to each be incorrect if I logically considered what those words said (Flowers, 2010).

Moreover, I had never actually been a fan of history, other than watching movies about wars. Social studies had been my worst class in high school, and the need to remember names, dates, and historical events seemed so far removed from my life that the motivation to learn was often absent. Decisions affecting the future seemed much more important. The fact that this field itself deals with technology, a rapidly changing area of study, reinforced my emphasis on the present and future. I even wrote once that it might be a mistake to ask undergraduates in technology teacher education to study the history of their field, as this may root them too solidly in the past (Flowers, 1997.)

After wrestling with the idea of providing direct instruction so that students would learn about the different philosophies of the field and about the history of the field, I came upon a different approach.

A Different Approach

Instead of teaching students what the philosophy of the field is, would it be possible for me to teach them to philosophize regarding technology education? That is, instead of teaching so they would learn philosophical content of the field, could I teach in a way that would first assist them in understanding philosophical processes and second to have them use those processes regarding the field? My background in philosophy would be a distinct asset. I could even use the Socratic method with these students as their understandings became better and better honed. In the course of doing this, quite a bit of the comparisons among historical eras could emerge. Delving deeply into an idea sometimes requires the learner to look at the history of the idea, and that approach to history was palatable.

If this approach were possible for addressing the philosophy of technology education (i.e., not just learning about the philosophy of the field but doing philosophy in the field), might it also be possible regarding the history of technology education. Could I ask students to play the role of a historian or a writer of history? Could I help them engage in original historical research? It would entail learning about and helping them use processes of historical research and writing, but if this were possible, might it become an empowering experience that helped them develop not just knowledge of history, but a personal relationship with it?

The Assignment

In the first semester this plan was implemented, this "local history" assignment charged each of the graduate students to compile an original history of formal and informal technology education and technical education in their geographic region, dating back to the earliest human inhabitants. Elsewhere in the course, materials related to the history of technology education were presented to students. They also worked on a separate assignment to report on a single historical movement in the history of the field. However, for the local history assignment, they were for the first time playing the role of the researcher and writer of history, rather than the role of the consumer of historical information.

Online learning materials were developed to assist students in historical research methodology. Topics included: the roles of historians; the scope of historical research; getting assistance in historical research; sources for historical research; assessing sources of historical information; using media in historical research; oral history methodologies; analysis and synthesis of historical information; and writing history. These can now be seen in a unit on historiography in technology education (Flowers, 2011). In addition, students were asked to participate in online class discussions addressing problems and issues that arose during this activity.

The work of each of these graduate students began with planning their own methods. They had to find out what historical information was available, and this included looking through yearbooks, old curriculum guides, old newspapers, information from historical societies, books on the history of the area, and more. They also planned to speak with key individuals. But when they started to uncover historical information and piece it together, the activity took on a life of its own. When these students looked through pictures from the past about local schools 80 years ago, when they found information about industrial training at a factory 120 years ago, or when they talked with someone about the history of early Native American cultures in the area, the information would raise questions that sent them in directions that seemed to multiply at every turn. Students' interests and own character became evident: some would explore connections to world events (e.g., world wars) or make connections to local events (a new industry coming to town); others would look at the plight of the teacher and student, the town's economics, or how discrimination was evidenced. Each student synthesized what was uncovered and learned, drawing conclusions about the overall evolution of formal and informal technology education and technical education in that locality up to and possibly beyond the present time. Part of what made this so difficult was the tendency to follow fascinating side roads where interesting historical information was uncovered that had little to do with the history of technology education and technical education, and students were encouraged to add such information to an overflow document that they could revisit later. The principle result was a separate historical account, published online by each of the students to their university webserver account; they were careful not to violate copyrights or the rights of those pictured or discussed.

Reactions to Initial Implementation

As the instructor, I can anecdotally report that this activity soon developed its own momentum, as students seemed to find internal motivation. They reported that they saw themselves as playing a role in preserving a historical record. Many noted that they were seen by school colleagues as the "resident expert" on local history.

Of special note are two comments from students. The first of these was in reference to an elderly subject who was interviewed, but who passed away just weeks after the interview; the student researcher attended the funeral, and shared with others there some of the wealth of information he had gained during that interview. He remarked that this was a unique and precious opportunity.

However, two other students complained of a problem in the design of the activity. It had been noted that this was a class-based report assignment, and was not intended to add to the historical record of the field by producing publishable information, as that would have entailed prior review by the institutional review board (IRB) for human subjects research. These students were frustrated at having put forward so much effort and care for this project, only to find that it would be inappropriate for them to add it to the historical record.

Therefore, a revised approach was developed and used in three later semesters. The students were required conduct interviews to gain oral histories, but to first go through human subjects research training and to submit research protocols for the human subjects portion of their local history activity. This covered, for example, the interviews they conducted, but not data that might have been gathered from the materials stored at their local historical society repository or library.

Outcomes

It could be argued that the local history of technical education is neither rich nor important. However, this activity can work as a lens through which students make connections with a wide variety of meaningful history. Although they were not all done under the auspices of the IRB, by the time of this writing, 46 local histories have been written from students in 10 different states. In some instances, students learned of the impact of early industries on technical education in their town. They saw evidence that African-American teachers were paid less than White teachers during the days of racial segregation. Classes that were for males only were a surprise for some to uncover, but hearing an elderly women speak of what that meant to her when she was a girl seemed to grip them. Seeing how both world wars impacted the nature of Industrial Arts curriculum raised issues of national needs and societal responses to particular crises through educational initiatives. Because this activity expected them to extend back to the earliest human inhabitants, and to consider nonformal technical education, there were ample opportunities for cultural appreciation.

Teachers should appreciate complex historical connections. The Standards for Technological Literacy (ITEA, 2007), suggest that technology education teachers ought to facilitate K-12 students in historical studies related to technology as a driving force; recall: "Standard 7: Students will develop and understanding of the influence of technology on history" (p. 79). Pannabecker (2004), however, suggested, "We must avoid teaching a simplistic ideology of 'effects' and a timeline of decontextualized artifacts and processes portrayed as a canon with a predictable, linear trajectory . . . Teaching a contextualized heritage will increase the field's capacity for reflection and analysis" (p. 80).

Later offerings of the class resulted in many benefits. For example, planning greatly improved. Students developed successive draft IRB proposals that were continually refined by comments from the instructor. When they met the instructor's criteria for approval, the students were cleared to submit these to the IRB, with the instructor signing as a faculty sponsor. A second benefit was that some students tended to look at their undertaking as something greater than the course. In later discussions with the instructor, it emerged that some students began to see themselves differently in relation to the field and its history. They had become some of those people who write the history of the field and the history of their town. This type of empowerment is not new to graduate education, though it may be unusual for it to emerge in the area of the history of the field. Several students noted at the end of the course that their reports were gratefully accepted as an addition to their local library or local historical society. A third benefit was reported long after this experience. The instructor of these students' research methods course noted that the learning and experiences associated with the local history activity were evident when the students participated in this class.

This activity also inspired the instructor: I used to shun history, and I now find it fascinating and captivating. I gained a new-found love of historical information as a direct result of guiding students through their experiences of unearthing and interpreting historical data. I became fascinated with the earliest issues of Industrial Arts Magazine and how some their contents from the time of World War I seemed amazingly appropriate for the present time. I also became fascinated for the first time with personal genealogy; even cemeteries were seen as historical data repositories rather than graveyards. In short, the excitement for historical research and thinking was contagious, changing both my relationship to the field in which I had been working for more than 20 years and my very world.

A Proposal

Even though there have been benefits to students from this activity, it might be that collaboration among institutions could be of benefit to the field. A proposal is therefore made to other teacher education faculty who address the history of technology education and technical education in their graduate programs, especially those that offer degrees through distance education that have learners situated in different communities working at schools. If a similar undertaking takes place at a variety of institutions, it may be possible to compile the information graduate students have generated, where they have given their permission, to form a richer picture of the history of the field in a regional, national, or international scope. This would further be supported by asking students to publish their work online, and after the course has ended, requesting their permission to allow the institution/instructor to archive a copy for distribution from the institutional web server. A national referatory could then point users to the locations of these documents.

Conclusion

There may be advantages in including historiography in graduate technology teacher education curriculum. This article began by explaining a case for this inclusion based on the nature of historiography and of the field. It then switched to a biographic narrative to illustrate a change in perspective that might be seen in actual historiography, invoking different reactions from the reader. Even though connections can be made to the nature of technology education and to secondary school history standards, it has also been shown that one instructor's personal path of revelations in teaching historiography has made a difference for him and his students.

For those who teach a graduate course in the history of technology education, or in the history of other areas of education, a proposal is made. First, can these classes include historiography and the writing of local histories of the field by students in these classes? Second, if that is possible, then can these local histories be compiled to become a larger mosaic that facilitates even greater levels of comparisons, cultural awareness, and historical understanding?

Further research on the inclusion of historiography in graduate technology teacher education could consist of studies to determine in what ways technology education graduate students apply their learning about historiography in their later teaching. The attitudes of these teachers can be compared to those who had not engaged in historiography, comparing in particular their appreciation of history, their feeling of connection to it, their ability to be critical of historical information, and their self-image as a writer of history. Future research can also examine the impact on K-12 student learning outcomes in history after historical content and methods are addressed in technology education classes.

Graduate technology teacher education students could work together to create a "Wiki" history of technology education adding new facts from their geographic location and editing the document to fit the times, as new history is created every day. This could be expanded beyond technology education to include all areas of education. A national referatory could serve to preserve historical information, allow connections to be made, and influence the very nature of the field and the views of those in the field.

Dr. Jim Flowers is a Professor and Director of Online Education in the Department of Technology at Ball State University, Muncie, Indiana. He is a member of Beta Chapter of Epsilon Pi Tau.

Mr. Brian Hunt is a Graduate Research Assistant in the Department of Technology at Ball State University, Muncie, Indiana.

References

Bailyn, B. (1994). *On the teaching and writing of history.* Hanover, NH: University Press of New England.

Blaszak, B. (2010). Preventing "back-atcha": Improving secondary school instruction by introducing prospective teachers to historiography. *The History Teacher, 43*(3), 435-439.

Bloom, B., Mesia, B., & Krathwohl, D. (1964). *Taxonomy of educational objectives* (Vols. 1-2). New York: David McKay.

Commager, H. (1965). *The nature and the study of history.* Columbus, OH: Merrill.

DeRose, J. (2009). Back to the future with textbooks: Using textbook passages from the past to help teach historiography. *The History Teacher, 42*(2), 229-237.

Fallace, T. (2009). Historiography and teacher education: reflections on an experimental course. The *History Teacher, 42*(2), 205-222.

Flowers, J. (1997). Teaching the historical perspective—Should we or shouldn't we? *The Technology Teacher, 57*(4), 7-8.

Flowers, J. (1998). Photography: An integrated technology education approach. *The Technology Teacher, 58*(3), 23-26.

Flowers, J. (2010). The problem in technology education (a definite article). *Journal of Technology Education, 21*(2), 10-20.

Flowers, J. (2011). Teaching historiography. Retrieved from http://jcflowers1.iweb.bsu.edu/rlo/mod historiography.htm

Galgano, M., Arndt, J., & Hyser, R. (2008). *Doing history: Research and writing in the digital age.* Boston, MA: Thompson.

Gottshalk, L. (1969). *Understanding history: A primer of historical method.* (2nd ed.). New York: Knopf.

Hoefferle, C. (2007). Teaching historiography to high school and undergraduate students. *OAH Magazine of History, 21*(2), 40-44.

International Technology Education Association [ITEA]. (2007). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

International Technology and Engineering Education Association. (n.d.). *This we believe.* Reston, VA: Author. Retrieved from http://www.iteea.org/AboutITEEA/ThisWeBelieve.pdf

Johnson, C. (2005). Herodotus who and annals what? Historiography and the history student. *Rethinking History, 9*(4), 521-528.

Loewen, J. (2010). *Teaching what really happened.* New York: Columbia University Teachers College Press.

Munslow, A. (2010). *The future of history.* New York: Palgrave MacMillan.

National Center for History in the Schools. (1996). *National standards for history.* Los Angeles: Author.

National Council for the Social Studies. (1994). *Expectations of excellence – Curriculum standards for social studies.* Silver Spring, MD: Author.

Pannabecker, J. (1995). For a history of technology education: Contexts, systems, and narratives. *Journal of Technology Education, 7*(1), 43-56.

Pannabecker, J. (2004). Technology education and history: Who's driving? *Journal of Technology Education, 16*(1), 72-83.

Petrina, S. (1998). The politics of research in technology education: A critical content discourse analysis of the *Journal of Technology Education*, volumes 1-8. *Journal of Technology Education, 10*(1), 27-57.

Stevens, R. (2001). *Homespun – Teaching local history in Grades 6-12*. Portsmouth, NH: Heinemann.

Following Engineering Graduates

Michael Feutz and Richard Zinser

This study provides an in-depth analysis of recent graduates' experience with completing an engineering technology program and entering the profession. It is unique because the study was conducted on a baccalaureate-level program and because it helps fill a gap in the literature. The phenomenological method was used to obtain qualitative data to understand the personal meaning of the process for the participants. Findings include positive perceptions about the curriculum and faculty, and some areas for improvement. The graduates found personal meaning especially in their capstone course and by being involved with the engineering student organization. There are implications for program evaluation and educational leadership.

Key words: program evaluation, phenomenology

The purpose of this study was to investigate the phenomenon of industry-employed graduates of the Bachelor of Science in Heating, Ventilation, and Air Conditioning (HVAC) Engineering Technology at Ferris State University (FSU) in Big Rapids, Michigan. In particular, the research sought to learn what the educational experience meant to the graduates, how they perceived they were prepared for work, what they consider to be the essential elements of the program, and what changes they would make to improve it. Most studies of Career and Technical Education (CTE) programs are quantitative in nature (Bozick & Macallum, 2002; Bragg & Russell, 1993; Brown & Conbere, 2005; Coryn, Gullickson, & Hanssen, 2004; Kagaari, 2007; Rahn, O'Driscoll, & Hudecki, 1999) and focus on descriptive statistics such as enrollment, retention, graduation rate, and employment rate. However, efforts to collect data related to how graduates apply their learning on the job and how they impact their place of employment are often neglected due the constraints of time and money (Zinser, 2003). Given the role of CTE to prepare students for success in the world of work, data related to graduate performance on the job might be more significant than statistical counts of student numbers, or student performance in school, in regard to curricular improvement. In many cases the industries that CTE programs serve are relatively unique so there may not be a benchmark against which quality can be measured; in that situation each program would need to be evaluated as a separate case, although a similar process may be used for different industries.

The Bachelor of Science in HVAC Engineering Technology does not fit neatly into any one-career cluster or serve a major industry. Created in the mid-1980s for a specific industry sector, it was designed to be more application oriented compared to a general engineering program, making it unique in higher education. In addition, it is a baccalaureate-level degree, whereas most CTE programs are placed at the high school and associate degree levels. The market for which it prepares students is not local or even regional; it is national and occasionally international in scale, yet the program itself is relatively small. Graduates accept jobs at companies that vary widely in size and scope; some have less than 10 employees and serve a local market while others have thousands of employees with branches throughout the world.

Similar to other institutions, FSU collects internal assessment data in the form of Academic Program Reviews; the last one conducted in 2006 indicated a high level of quality as perceived by key stakeholders, including students, graduates, employers, faculty, and advisory committee members. Participants responded to typical survey questions and provided short, one-sentence comments for a number of open-ended questions. The data provided by the Academic Program Review was mostly positive and provided a basic quantitative measure of stakeholders' perceptions of quality. Responses to open-ended questions provided supplementary information, but sufficient data were not available for analysis. Further, the use of a simple survey instrument is inadequate for additional probing and in-depth questioning. In order to gain a better understanding of how quality in the program is achieved and what opportunities exist for curriculum improvement, a more in-depth analysis using a qualitative design was necessary.

Background Literature

Program Evaluation

Evaluation is a process that determines the worth of something. In education, evaluation is commonly used to assess the value of specific courses for students. Rarely however is a complete program submitted to a rigorous evaluation by external standards. Yet most technical education degree programs have a built-in accountability to the community that hires its graduates; the curriculum and equipment must be kept up to date according to what is used in the industry. Evaluation therefore can serve as an audit of a program to solicit ideas for improvement and to resolve any problems (Zinser, 2012). The procedures for conducting evaluation studies vary along a spectrum of complexity. An evaluation could be mostly informal such as asking students how they are doing in the program; second, the process might be semiformal by including discussions with an advisory committee or representatives from the related industry; third, a formal evaluation is sometimes conducted by an external reviewer much like a research project. Similarly, what gets evaluated can range from a single course to the entire system required for the program to function: funding, facilities, curriculum, faculty, student participation, learning objectives, and final outcomes such as employer satisfaction with the graduates. Many different data collection methods can be used, depending on the aspect of the program under study.

An evaluation approach that has been used in industry for many years is the four-level valuation developed by Kirkpatrick (1994). Although it was designed for corporate training programs, not necessarily for education, there are some similarities that can be readily adapted.

1. **Reaction:** measures how the participants liked a specific learning experience; it could include their perceptions about the teacher, the content and methods, and even logistics such as the facility and schedule. The participants should have positive reactions in order to motivate them to continue learning about the topic and to use the skills in practice. Student opinions are typically measured with simple feedback forms at the end of the course and the results are generally used informally by the instructor to make adjustments as necessary.

2. **Learning:** measures how much the participants improved knowledge, increased skills, and changed attitudes resulting from a course. The assessment of learning is the most common evaluation method used in education, for which educators have considerable expertise. Teachers use a variety of written tests to measure specific learning objectives especially at the knowledge level. The assessment of skills is more widespread in technical subjects and is accomplished through performance demonstration by the learners. Measuring student attitudes is less common, perhaps due to the intangible nature of the affective domain; however, an attitude such as safety is important in technical education and can be measured indirectly by observation of specified activities.

3. **Behavior:** measures the extent to which students changed their behavior as a result of the educational experience. (It actually focuses on job performance, not “behaviors” like attendance.) To measure behavior it may be difficult to isolate the effects of the training because of other variables such as learner motivation, the work procedures, and organizational climate. This evaluation level is more challenging and time-consuming because it requires follow-up with participants after the training, but such an analysis can provide meaningful feedback about the program. By asking former students how they perceive they were prepared for work, faculty may discover that students believe there are some gaps and some redundancies in the curriculum, for example, which could be easily corrected. Evaluating behavior is best done through pre- and post-measurements of performance and by conducting interviews with the participants and their supervisors.

4. **Results:** refers to the actual benefit for the organization from the educational experience and is usually expressed in “bottom line” measurements such as reduction of errors or increased profits. Although this may be the most important level for the employer, it is also the most challenging to quantify the results of education. In the context of program evaluation, however, employers usually expect that graduates have the right skills, which reduces their training cost, and that the number and quality of prospective workers has increased. Evaluators of a program must utilize well-defined success criteria to demonstrate its value, and when a program is regarded as successful, the organizations are very likely to support the program and even increase their support.

Knox (1998) developed a comprehensive model for program evaluation involving eight stages, coordination, and interpersonal considerations. This process is similar to project management in general, but the key concepts for the current discussion are the identification of stakeholders and agreement on exactly what should be measured (or the success indicators). For technical education, external stakeholders are usually the employers who hire the program's graduates, and the measures of success are the sufficient number and quality of prospective employees. The data collection methods are then chosen depending on the nature of the data source. For example, student or graduate perceptions are commonly measured by surveys, interviews, and focus groups. Advisory committee members or other experts who employ the graduates are usually interviewed. The curriculum can be assessed by comparing its objectives with professional content standards.

Therefore, the effectiveness of college education, as measured only by knowledge of student learning (Millett, Stickler, Payne & Dwyer, 2007), is not a sufficient evaluation. To increase accountability, more CTE programs may need to conduct follow-up studies with their graduates and the companies that employ them. Key stakeholders need to know that the program is relevant: professors want to know that their teaching is meaningful, administrators want to know that funding is justified, employers want to know where to find qualified employees, and prospective students want to know how their program of study will prepare them for the world of work (Feutz, 2010).

A quantitative design such as a follow-up survey describes the characteristics of the program and its graduates as a statement of the numerical value of one or more observable parameters (Glass & Hopkins, 1996). The extent to which graduates perceived they were prepared in areas of specific course material and the importance of that material to their job can also be measured. Similarly, a scaled survey is sometimes used to measure the extent to which employers believe graduate employees exhibit attributes of skill, knowledge, and attitudes. Such evaluations may be more common than is known through the literature, likely because institutions use the results for internal purposes. Although valuable, these data generally do not explain how course materials or graduates' attributes contributed to job success, nor could they explain what was useful about the material or attribute (Feutz, 2010). In contrast, a qualitative design answers "how" and "what" questions that allow exploration at a deeper level of understanding through inquiry (Creswell, 1998; Locke, Spirduso, & Silverman, 2007; Marshall & Rossman, 2006).

Qualitative Research

Many traditions or methodologies of qualitative inquiry exist; each one has unique features and characteristics for various types of study. Though many studies combine elements of two or more traditions (Creswell, 1998), this study most closely aligns with the characteristics of a phenomenology. A phenomenological approach is best employed in situations bounded by temporal and physical limits (Lancy, 1993), and it is used to study the lived experiences of several individuals to describe the "essence" of a phenomenon through the personal meanings of that experience from the subjects' perspectives (Bogdan & Biklen, 2003; Burke & Christensen, 2004; Creswell, 1998; Marshall & Rossman, 2006; Patton, 2002).

This study used a phenomenological design to gauge the alignment of the HVAC Engineering program with its industry, as measured by the perceptions of graduates. A phenomenology is used to study a specific experience shared by a relatively small number of people, purposefully chosen as a nonrepresentative sample (Bogdan & Biklen, 2003), using a systematic yet flexible in-depth interview structure based on open-ended questions (Bogdan & Biklen, 2003; Burke & Christensen, 2004; Creswell, 1998; Marshall & Rossman, 2006; Patton, 2002). The phenomenological method was chosen for this study because it offered opportunities to interact with subjects on a human-to-human basis, to explore further if necessary using follow-up questions, and to arrive at conclusions post hoc rather than a priori (Creswell, 1998; Lancy, 1993). Through this method, the research progresses inductively, with the researcher trying to make meaning out of the data. Preconceived notions or conclusions are not a part of qualitative inquiry, because they may cloud the researcher's findings (Bogdan & Biklen, 2003; Marshall & Rossman, 2006). Rather, the researcher attempts to remain as open-minded as possible, so that the meaning emerges from the data. Such a strategy allowed the exploration of the subjects' perception of the

HVAC program in great depth to determine the extent to which graduates were successful in the school to career transition. A qualitative assessment can bridge the gap between measures of school performance and job performance (Bragg & Hamm, 1996).

Research Questions

To comprehend the phenomenology of engineering graduates, the following research questions were employed:

1. What does the HVAC program mean to its graduates on a personal level?
2. How do graduates perceive they were prepared for their careers?
3. What are the essential core academic, general education, and nonacademic elements of a relevant HVAC program?
4. What changes, if any, could improve the HVAC program from the perspectives of pedagogy and relevance?

The answers to these questions reflect the perceptions of the graduates who participated in the study. These data provided a detailed portrayal of the strengths and weaknesses of the HVAC degree. Perhaps more important, the study brought to light what the degree means to graduates. These data supplied several measures of program quality and will be used as a basis for program improvement. The evaluation process may also be employed for other CTE programs.

Methods and Procedures

To recruit subjects for the study, contact information for all 110 HVAC graduates from the years 2007, 2008, and 2009 was solicited from the FSU administration. The size of the sample was relatively small, as is common in qualitative inquiry (Bogdan & Biklen, 2003; Creswell, 1998; Locke, Spirduso, & Silverman, 2007). The sample was also purposeful and involved only graduates from these three years. The reason for this delimitation was to interview those who were relatively new to the workforce. As time passes, it may be more difficult for graduates and employers to determine which knowledge and skills were learned in school and which were acquired through experience on the job. Therefore, subjects were not too far removed from their educational experience yet they have been in the workforce for a sufficient time to allow for reflection. The companies that employ the graduates vary by size, scope of work, geographic location, and geographic market.

After receiving approval from the university's human subjects review board, all potential subjects were invited to participate via an email message, and a second invitation was sent one week later to those who had not replied. A goal for the subject selection was that the experiences of both on-campus (n = 88) and online (n = 22) graduates would be represented; though the ratio of campus to online graduates is four to one, a similar sample size would have allowed for a comparison of themes between groups if that phenomenon arose. A total of 21 graduates (19%) responded to one of the two emails; 18 were successfully contacted and expressed willingness to participate. This sampling provided a diverse, nonrepresentative group. Because of the small number of program graduates, and the narrow focus of the study, the results are limited and should not be generalized to other populations or programs, although the evaluation process could be replicated widely.

The instrument of inquiry for this research was the open-ended, in-depth interview protocol, consisting of the four basic questions that were conducted over the phone due to the geographic separation among the subjects, and these were recorded to ensure accuracy. Qualitative interviews are conversational and exploratory, beginning with social conversations, and based on a few general topics (Moustakas, 1994). The subjects' responses were allowed to unfold in whatever form they wished to frame the discussion. The open-ended questions were designed to obtain data in a way that did not lead the subjects (Marshall & Rossman, 2006).

A total of 18 interviews were conducted. Ten of the subjects graduated from the traditional on-campus program and eight graduated from the online version, which presented an opportunity to analyze an additional variable. The two groups are highly differentiated by their age and years of experience (Figure 1); the on-campus participants were generally traditional college-age students, whereas the online students were typically aged 30s to 50s and already working in the field. Participants were asked to reflect on their educational and work experience and to explain how they felt they were prepared for their jobs. Follow-up questions were asked as

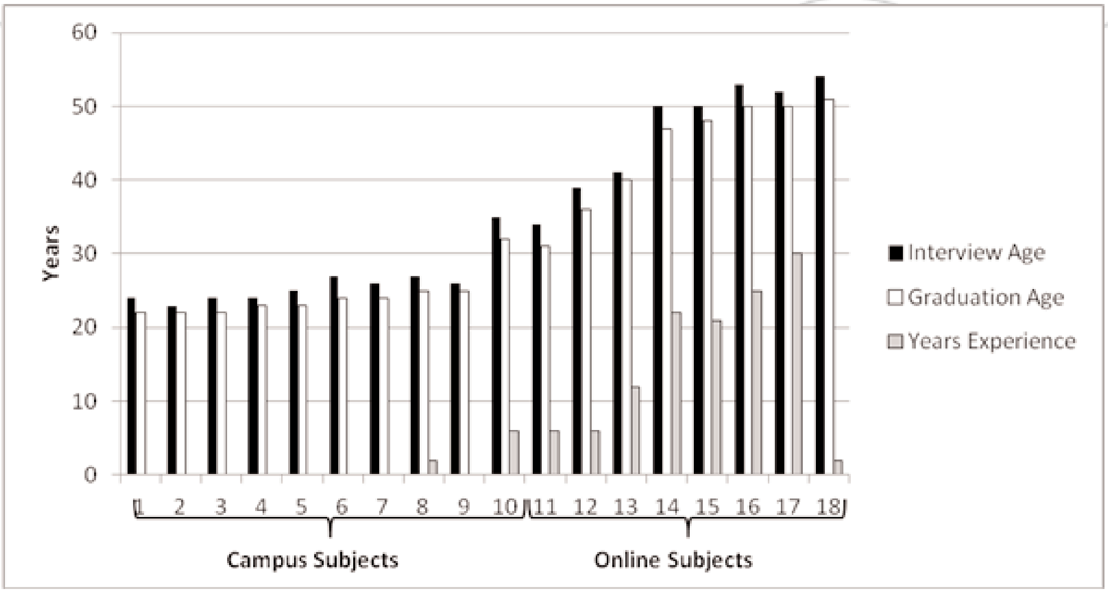

Figure 1. Subject Demographics

needed. Code numbers and pseudonyms were developed to provide anonymity. After the interviews, "member checking" was used to validate interpretations and descriptions of the experience. This involved asking interview subjects to review the transcripts in order to ensure that the experience was captured accurately from the perspective of the subjects and with minimum bias (Burke & Christensen, 2004). To organize the data, audio recordings of each telephone interview were transcribed; the data was coded via Excel through a process known as "phenomenological reduction" (Creswell, 1998). During phenomenological reduction, the researcher seeks to discover facts and themes that disseminate from the data; the researcher sets aside beliefs and knowledge of the phenomenon so that the true essence can be discovered from the perspective of the subjects. In all, 58 distinct headings were created to code the data. The headings were then clustered with other headings of similar meaning into six main themes that emerged in the study.

Findings

Based on the responses to the four research questions, six common themes (Figure 2) emerged for both campus-based graduates and online graduates. In general: (a) graduates think positively about the HVAC curriculum; (b) general education does not contribute significantly to the HVAC experience; (c) graduates find deep personal meaning in the HVAC experience; (d) assets and attributes of the program and the university contributed significantly to the positive experience of the graduates; (e) graduates are well-prepared for work; and (f) there is room for improvement. These themes are discussed in the following sections, which include a few highlights of how campus and online graduates differed. Pseudonyms are used whenever a subject's name appears.

Theme One: Strong Positive Attitude Toward HVAC

All subjects who graduated from the campus program chose the degree because it seemed to be a fit, piqued their interest, or allowed them to

1. Positive Attitude: *Focused curriculum *Challenging courses	**2. General Education:** *No direct value *Communication skills
3. Personal Meaning: *Gratitude *Self-fulfillment	**4. Quality Educational Assets:** *Supportive faculty *Student organizations
5. Graduates well prepared: *Work-based learning *Early responsibilities	**6. Suggested changes:** *Professional accreditation *Project management

Figure 2. Graduates' Thematic Perceptions

advance in their careers. Of the factors cited for making their decisions, subjects often spoke of the concentration on HVAC and the narrow focus of the program. Nick described how FSU helped him find a direction in school: Tony described how the program had given him an advantage over graduates of mechanical engineering programs that "just taught theories" and were "broad spectrum," whereas FSU was "very precise."

Though some subjects said they were good at it while in school, they also found the curriculum "challenging" or "difficult." At the same time, they saw the value in the challenge via the knowledge they gained. Subjects discussed the curriculum as a whole, but they also used individual courses to make their point from time to time, whether talking about their experience in school or on the job. The first course taken during the first semester of the HVAC program (HVAC 331 Secondary System Selection and Design) was described by some of the subjects as somewhat of a gateway course to the program. Where subjects saw HVAC 331 as a gateway to the degree, they saw the capstone course as culmination of their learning, and sometimes as their rite of passage. HVAC 499, as the capstone course, allows students to concentrate in an area of interest to them. Each year, students of the HVAC program submit their HVAC 499 capstone projects to be judged in an international student design competition. For John, HVAC 499 had the same effect. It focused the program, it had significant meaning for him, and it provided him with insight for his career.

Theme Two: General Education Courses

The investigators were interested in a holistic view of the HVAC degree. This included not only the core courses, but also the general education courses that are required for graduation. Overall, the responses were mixed. Unlike subjects who remembered specific HVAC courses and details within specific courses, these participants sometimes struggled to remember individual general education courses they had taken. Others mentioned a specific course that had meaning for them, or piqued a personal interest. Communication courses were most often cited as helpful. Josh said, "I guess you could say it helps you become a well-rounded person."

Theme Three: Personal Meanings--Pride, Gratitude, Self-Fulfillment

For the campus graduates, the strongest personal meaning was a feeling of pride in earning the degree. Although that feeling was not always explicitly stated, it was inherently obvious during the conversations, particularly when the subjects described their accomplishments on the job and their skills relative to coworkers who had earned their college degrees elsewhere. Josh, Brian, David, Brandon, Jordan, and Tony had all used coworkers or other graduates as a benchmark for their skill set. David had much stronger feelings and spoke at length about his gratitude, saying that the program and the faculty:

> have contributed to an excellent three years in the real-world and a great excellent four years in the college world as well . . . [It has] put me in many of the positions of success that I enjoy to this day, and I am very, very grateful . . . I do owe . . . a great deal of gratitude and thanks for the things that I get to enjoy in life now.

For others, the degree represented an opportunity to grow; it gave them a feeling of accomplishment and perhaps even self-fulfillment. Tony thought the experience "was pretty significant." He explained, "I felt that it was definitely a significant change that someone like me who is technical based, um, you know, struggles in English, struggles in just schooling in general that wasn't technical . . . I never thought that I would be able to do something like that."

Theme Four: Quality and Supportive FSU Educational Assets

"FSU assets" is a term to describe the characteristics of the experiences that had meaning for the subjects. The curriculum is a prime example of a characteristic. For many, either a favorite professor or the faculty in general were significant. Jack spoke both of his feelings for the faculty and of his perception of their attitude: "I liked every single teacher; they really did put a good effort into wanting you to learn the subjects." For Josh, the faculty members were included as factors in his personal growth: "The program and the teachers in the program really helped me become who I am today."

Second, several of the subjects discussed the social aspect of their campus experience, including personal interaction with faculty. Friendships were forged that had a meaningful impact on the lives of others. David's story is a perfect example. He actually landed his job based on information received from a friend. The third asset mentioned is the HVAC

Building, which was built in 2003 and designed with the mechanical, electrical, and plumbing systems exposed to enhance teaching and learning. The subjects involved in this research were among the first students to take courses in the new structure and the features of the building resonated with them. Many mentioned that the facility impressed them while visiting campus, and they enjoyed taking classes there for two years.

Another asset of the FSU program is the engineering student organizations; all but two campus subjects mentioned the organizations as significant. These student organizations provided opportunities for the subjects while they were on campus. In addition to campus activities, each organization hosts an annual conference, convention, or exposition at various locations throughout the United States. Students raise funds to attend or find sponsors to fund their travel expenses. Some of the organizations also sponsor student competitions, including the HVAC design competition that subjects spoke of on several occasions. Involvement in these organizations proved to be a significant element of many of the subjects' experience, particularly the opportunity to travel. Through the student organization sponsored trips, the subjects saw different parts of the country, developed their networks, and discovered new opportunities within the industry.

Theme Five: Well-Prepared Graduates

The overarching question for this study was: How do graduates perceive they were prepared for the industry as measured by what they know and know how to do as compared to what they need to know and be able to do? This theme answers that question, although it was often difficult if not impossible to extract and then separate salient points related to curriculum and work. Subjects used work examples to make their points when discussing the curriculum, and they used the curriculum to make their points when discussing their work.

Internship. The discussion began with the internship because, as both a required course and work experience, it illustrates the intricacy of the relationship between school and work in the HVAC program. As the first exposure to a full-time work experience for many subjects, the internship made the all-important connection between the world of school and the world of work, and, indeed, directly linked half of the campus subjects to full-time employment. Josh, Brian, Austin, Jack, and Tony parlayed the internship they served between junior and senior years into full-time employment upon completing their last year of school. A mock interview held during an advisory board meeting led to an official interview and subsequently a job for John. Many of the subjects spoke at length about the internship and their experiences. Comments from Josh's interview demonstrated how the internship provided the opportunity for an individual to "transition from an uncertain young college student to a confident young man ready to tackle the workforce."

During his internship, he gained experience with one manufacturer's controls in particular and learned controls using equipment from another manufacturer in the labs at FSU. Though neither company hired him, his portfolio documented his internship experience and helped him secure a job upon graduation with a third controls company. Since he "already knew two of our competitors' control systems," he found that the knowledge and experience gained through the internship and at school "helped out in certain scenarios." In hearing of the internships from the viewpoint of the subjects, it became evident that experiences were particularly significant to them. The internship seemed to be a transformational point in their lives, and as Josh articulated, "[he] grew up." It also gave them a chance to apply their knowledge and gave them confidence in what they knew and could do.

Another comparison between FSU graduates and other graduates was offered by Tony, who described how the limited expertise that he gained in HVAC 451: Energy Analysis and Audit led to considerable responsibilities for him on the job:

> I am the only person at [my company] that has done any energy modeling . . . we've got a full floor above me upstairs that is project engineers, project managers, and full-blown P.E.s [Professional Engineers] and they've never done energy and that is something that they really look to me . . . to help them . . . justify energy programs and energy projects and . . . retrofit opportunities.

Whereas conducting energy auditing has simply been added to the responsibilities of both Tony and John, David actually carries the title of Energy Engineer. This is a position he secured because of the knowledge he gained through the HVAC program and HVAC 451 in particular. David's description of his duties read like the 451 course description.

Deep End of the Pool. Many subjects found themselves with significant responsibilities soon after beginning their job. Most often, though not always, this was a confidence builder for the subjects. For Tony, as the only employee at his firm capable of performing energy audits, the knowledge that he acquired in HVAC 451 amounted to a double-edged sword. Out of school only one year, the responsibilities that he had gained were a bit intimidating, yet through his knowledge, limited though it was, he gained the trust of his superiors and colleagues.

Theme Six: HVAC Is Not Perfect

Asking, "What would you change about the program?" enabled the interviews to take on a richer and more in-depth narrative describing the experiences of each subject. Two topics came to the surface: the lack of professional accreditation and the need for a business-related course. In brief, the HVAC program is not accredited by the Accreditation Board for Engineering and Technology. This was a conscious decision by FSU to provide a more narrow industry focus rather than the broader mechanical engineering program. However, this choice prevents graduates from becoming licensed or registered as professional engineers (P.E.s). HVAC graduates can do everything a P.E. can, but they lack the authority to sign or "stamp" engineering documents and take legal responsibility for them.

The second main subtheme to appear under opportunities for improvement was the addition of a course, or at least learning objectives, related to the business side of the industry. Representing the perspective of other subjects, Tony felt that he was not prepared for the "whole management of time and people and resources. I felt like I wasn't really prepared enough." Along the same line of thought, Brandon said, "one of the things I felt was a weak point is just learning about the different parts of a job . . . how the whole bid process works and how a job evolves."

The Online-Degreed Graduates

All of the online graduates who participated in this study chose the online option for its convenience. All were employed while earning their degrees, and with all but one living outside of the state, they were able to continue working and living at home. For the online subjects, the curriculum varied in meaning from the campus subjects. Though they certainly felt it was a "real-world" experience as the campus subjects did, they also found it to be enlightening. Because they already had extensive industry knowledge, some found there was much more to know and learn. Others found portions of the curriculum to be familiar territory, thus validating the work they had been performing during their careers. With his extensive field experience, Nathan found the HVAC program to be enlightening. While in the field, he had known enough to "make the stuff work" but he did not always understand why (which seems to be the reverse of campus students). Online students also spoke about the capstone project and its real-world application. Josh said: ". . . and the situation that you run into in real life is there may be more than one solution to a problem and it's up to you to decide which solution you want to use to best help that customer. And it's not textbook, although you do use textbooks to come to a solution if you have questions about a particular situation."

For the online subjects, interaction with faculty was limited to electronic or phone communications, with one exception. As students, they started in the fall of their enrollment year with the first HVAC course. During the winter semester they took the second HVAC course, followed by the third during the summer. In August of that first summer, they all traveled to campus for a five-day hands-on laboratory learning experience. During this time they met each other, their professors, and their advisor for the first (and only) time. Several graduates commented that faculty members were highly regarded in the industry, and it was rewarding to meet them in person.

Many of the social aspects of college can be lost in the online format, particularly when the students are scattered across the country as they are in the HVAC online program. Yet the subjects managed to find social interaction with fellow students and with the faculty and staff of the university and established meaningful relationships in the process. John related that "as I went on [in the program] I got introduced to students that were online and we formed a network where we could discuss things with people from different parts of the country."

To enhance online learning, faculty recorded and edited their lectures and provided students with CDs containing all the lectures and other materials that were needed to supplement written materials. Faculty members were pleased to hear that students believed the CDs were effective tools. As Tyler noted:

> I think CDs are the way to go because the student can get out of school and he can refer back to those CDs for years . . . I thought that was excellent . . . that is very important. I'm the type person that when I go to a class, especially one that is important in my field, I keep all that data and I categorize it and put it in notebooks or crates. And that way I can refer back to it over and over as I have in the past.

Other subthemes emerged when subjects were asked what they would change about the HVAC program. Online graduates noted that some of the materials they received either contained errors or were outdated. There was a delay in communication associated with online learning. Subjects cited specific courses where feedback from their professor was delayed by up to a month. One subject expressed the feeling they were "drifting for several weeks at a time." Even with the normal communication lag expected when using electronic communication in the form of email, when faculty schedules did not align with student schedules, the students had no way to ask a question and get an instant response unless they happened to be in a live chat room. Because they had full-time jobs, subjects found themselves working on their courses during the nights and weekends, which were often the times when faculty were not at their computers. Greg did not comment on communication issues, but he did complain that general education courses were difficult for online students to take because of the limited offerings. He acknowledged that FSU had added more courses as time went on, but for him, many of those courses came too late and he struggled to find the general education courses that he was required to take.

Review of differences. To summarize the comparisons between the two groups of graduates, several facts differentiated online subjects from the campus subjects relative to the world of work. First, for the campus subjects, their internships were significant features of their HVAC experience. The internships led to full-time employment, provided the connection between school and work, and helped the students mature. The online subjects did not serve internships. Though the internship was required of them, their HVAC-related job experiences allowed them to earn their internship credits though a proficiency-by-portfolio process. Also, because they had an average of 15.5 years of work experience, the internship would not have provided the same meaningful introduction to the world of work as it had for the campus subjects.

Second, while the campus subjects felt they entered the job market at the "deep end of the pool," the online graduates had already been in the "pool" for years, so while this was a significant experience for the campus subjects, it was not a factor for the online subjects. Third, the campus subjects measured themselves against their coworkers who had graduated from other institutions, and often with a degree in mechanical engineering. The campus subjects believed they were better prepared than their counterparts. That experience did not emerge with the online subjects, as they were seasoned veterans with significant expertise even before they earned their HVAC degree; thus, there was no need for them to find a benchmark against which they could measure themselves. Finally, some of the online students needed the baccalaureate degree to either secure their job or to be eligible for promotion within the same company. Like some others, Steve did not need a baccalaureate degree for employment or promotion purposes, having progressed far into his careers with only an associate degree, but he wanted a baccalaureate for reasons of personal fulfillment.

Discussion

This phenomenological study served as a tool for program analysis and improvement. When asked about their experiences, the subjects defined their personal meanings using specific elements of the program. When viewed from the perspectives of its graduates, the strengths and weaknesses of the program became apparent, and two critical elements of its invariant structure emerged. First, the program aligned sufficiently well with students' needs and interests in a technical degree to be described as a good fit for them. Second, the data revealed that the curriculum aligned precisely with the sectors of industry for which it was designed. Because of these alignments, graduates perceived the program as the premier educational experience in their field and exhibited feelings of great personal pride and a sense of accomplishment due to their affiliation with and graduation from it.

With the long history of CTE as workforce development or education for jobs, and federal legislation to regulate that education, this study reinforces the importance of a curriculum that is aligned with the industry for which it prepares its students, and it provides strong evidence that a unique CTE program can and does have a role in the current educational system. The strong feelings of the participants that the HVAC program fit their needs, provided excellent preparation for their careers, and fostered a strong sense of job security seem to highlight the merit in narrowly focused CTE curricula.

From the perspective of credibility, though the public perceives CTE as something less than academic (Cohen & Besharov, 2002), the pride and success projected by the participants of this study indicate just the opposite. This carries the implication that quality CTE programs can have as high a value as academic programs. It follows that efforts to increase the quality across the spectrum of CTE could improve its perception in the public eye. In addition, publishing and promoting the results of effective programs can help demonstrate their significance. An important distinction must be pointed out: the HVAC program is a baccalaureate-level degree. This is an anomaly within CTE, as the vast majority of programs exist at the secondary or associate degree level. Perhaps this study makes an argument for elevating more CTE programs to the baccalaureate level.

Though existing quantitative data had indicated a high level of quality in the HVAC program, this qualitative study provided answers to "how" and "why" questions and identified areas of strength and areas of weaknesses in which quality improvements could be made. In fact, the study would still be valuable to the college even if the results were more negative. To further the research, perhaps the qualitative findings from this small sample could be used to develop a quantitative survey instrument for administration to a larger sample to provide results that would be more generalizable, so that the evaluation process could be replicated for other CTE programs.

Michael Feutz teaches Heating, Ventilation, Air Conditioning and Refrigeration Engineering Technology at Ferris State University, Big Rapids, Michigan.

Dr. Richard Zinser is a teacher-educator in vocational education at Western Michigan University, Kalamazoo.

References

Barlow, M. L. (1976). History of CTE. American Vocational Journal. Retrieved from http://www.acteonline.org/ctehistory.aspx?terms=history.

Bogdan, R. C., & Biklen, S. K. (2003). *Qualitative research for education: An introduction to theory and methods* (4th ed.). Boston, MA: Allyn and Bacon.

Bozick, R., & Macallum, K. (2002). *Does participation in school-to-career limit students' educational and career opportunities? Findings from the LAMP Longitudinal Study.* Academy for Educational Development, Washington D.C. Retrieved from http://www.eric.ed.gov./ (ED475123)

Bragg, D., & Russell, E. (1993). *Linking college and work: Exemplary policies and practices of two-year college work-based learning programs.* National Center for Research in Vocational Education, Berkeley, CA. Retrieved from http://www.eric.ed.gov./ (ED396155).

Bragg, D. D., & Hamm, R. (1996). *Linking college and work: Exemplary policies and practices of two-year college work-based learning programs (MDS-795).* Berkeley: National Center for Research in Vocational Education, University of California at Berkeley. Retrieved from http://www.eric.ed.gov./ (ED396115).

Brown, J., & Conbere, J. (2005). *A quantitative case study focused on using a human resource development system to analyze the program performance assessment strategies of federally funded career and technical education programs in 12 Minnesota technical colleges.* Online Submission; Paper presented at the Academy of Human Resource Development International Conference (AHRD) (Estes Park, CO, Feb 24-27, 2005) pp. 1132-1137 (Symp. 49-2). Retrieved from http://www.eric.ed.gov./ (ED492277)

Burke, J., & Christensen, L. (2004). *Educational research: Quantitative, qualitative, and mixed approaches.* Boston, MA: Pearson Education.

Cohen, M., & Besharov, D. (2002). *The role of career and technical education: Implications for the Federal Government.* Paper commissioned for "Preparing America's Future: The High School Symposium" (Washington, DC, April 4, 2002). Retrieved from http://www.eric.ed.gov./ (ED466939).

Coryn, C, L., Gullickson, A. R., & Hanssen, C. (2004). *Assessing the impact and effectiveness of the Advanced Technological Education (ATE) Program.* Kalamazoo, MI: The Evaluation Center, Western Michigan University. Retrieved from http://www.wmich.edu/evalctr/ate/publications

Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions* (1st ed.). Thousand Oaks, CA: Sage.

Feutz, M. (2010). *The Phenomenology of the Bachelor of Science in HVAC Engineering Technology from Ferris State University.* (Unpublished doctoral dissertation). Western Michigan University, Kalamazoo, Michigan.

Glass, G. V., & Hopkins, K. D. (1996). *Statistical methods in education and psychology* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Kagaari, J. R. K. (2007). Evaluation of the effects of vocational choice and practical training on students' employability. *Journal of European Industrial Training. 31*(6), 449-471.

Kirkpatrick, D. (1994). *Evaluating training programs: The four levels.* San Francisco: Berrett-Koehler Publishers.

Knox, A. (1998). *Evaluating adult and continuing education.* Columbus, OH: ERIC Clearinghouse on Adult, Career, and Vocational Education.

Lancy, D. F. (1993). *Qualitative research in education: An introduction to the major traditions.* White Plains, NY: Longman.

Locke, L. F., Spirduso, W. W., & Silverman, S. J. (2007). *Proposals that work* (5th ed.). Thousand Oaks, CA: Sage.

Marshall, C., & Rossman, G. B. (2006). *Designing qualitative research.* (4th ed.). Thousand Oaks, CA: Sage.

Millett, C. M., Payne, D. G., Dwyer, C. A., Stickler, L. M., & Alexiou, J. J. (2008). A culture of evidence: An evidence-centered approach to accountability for student learning outcomes. *Educational Testing Service.* Retrieved from http://www.acteonline.org/uploadedFiles/About_CTE/files/EvidenceCenteredAToAcc.pdf

Millett, C. M., Stickler, L. M., Payne, D. G., & Dwyer, C. A. (2007). A culture of evidence: Critical features of assessments for postsecondary student learning. *Educational Testing Service.* Retrieved from http://www.acteonline.org/uploadedFiles/About_CTE/files/CriticalFAPSecSL.pdf

Moustakas, C. (1994). *Phenomenological research methods.* Thousand Oaks, CA: Sage.

Patton, M. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Rahn, M. L., O'Driscoll, P. & Hudecki, P. (1999). Taking off! Sharing state-level accountability strategies using academic and vocational accountability strategies to improve student achievement. *NCRVE Materials Distribution Service.* Retrieved from http://www.eric.ed.gov./ (ED431138)

Zinser, R. (2003). Evaluation of a community college technical program by local industry. *Journal of Industrial Teacher Education. 40*(2), 51-64.

Zinser, R. (2012). The evaluation of technical education programs. Manuscript submitted for publication.

The Impact of In-Service Technology Training Programmers on Technology Teachers

Mishack Gumbo, Moses Makgato, and Heléne Müller

Abstract

The aim of this paper is to assess the impact the Advanced Certificate in Education (ACE) in-service technology training program has on technology teachers' knowledge and understanding of technology. The training of technology teachers is an initiative toward teachers' professional development within the mathematics, science, and technology sphere of education (MSTE). ACE is a two-year training program that technology teachers in the Gauteng and Mpumalanga Provinces (South Africa) attended during 2008 through 2009. The program attendees were senior phase teachers, of whom a few taught in the Further Education and Training band of education (certain high schools begin with grade 8). The research problem that the study addressed is stated in terms of the following hypothesis: There is no statistically significant difference between the pre- and post-knowledge and understanding survey scores for teachers attending the ACE professional development program in technology education. A survey questionnaire to collect biographical and technological input was administered to teachers who attended on the days the questionnaire was administered. The same questionnaire was administered at the beginning of training in 2008 and at completion of the program in 2009. The aim of the quantitative study was to evaluate whether the ACE-Technology training had a statistically significant impact on technology teachers' knowledge and understanding of technology. In total, 304 completed questionnaire responses were included in the study. The results indicated that there were improvements in the teachers' technological knowledge and understanding. This indicates that teachers benefited positively from the ACE-Technology training.

Keywords: Advanced Certificate in Education, in-service training, technology teachers, technology teaching capabilities, professional development programs, MSTE education, nonparametric Kruskal-Wallis test, Wilcoxon test.

Background Of The Study

The introduction of outcomes-based education (OBE) in the form of Curriculum 2005 (C2005) was a huge educational reform in the history of South Africa. C2005 was reviewed twice and became consecutively known as the Revised National Curriculum Statement (RNCS), the National Curriculum Statement (NCS); currently it is the Curriculum and Assessment Policy Statement (CAPS). It is envisaged that CAPS will be implemented in 2012 (Department of Education [DoE], 2005, 2010). The reviewed versions have not lost their OBE flavor per se, as the present version is still undergirded by the curriculum principles rooted in the South African *Constitution's* "Preamble," which motivated the transformative OBE curriculum approach (DoE, 2003, 2010).

The OBE approach to the curriculum created a gap between the requirements of the OBE and training the majority of teachers previously received (Ono & Ferreira, 2010). Because the pedagogic practice of the OBE differs from previous practice, intensive, continuous professional teacher development is imperative to prepare teachers for the implementation of the revised curriculum. The urgency of the matter becomes even more apparent considering the training of underqualified and unqualified teachers is still incomplete and a reality to be dealt with (Jansen & Christie, 1999; Taylor & Vinjevold, 1999). Although the qualifications of many teachers in the country have improved, the majority of teachers have not been sufficiently equipped to meet the changing educational needs of modern society (DoE, 2006). Two of the most important factors in determining whether teachers are adequately equipped to teach technology successfully are content knowledge (subject matter) and pedagogic skills (Aluko, 2009). Most studies in teacher development have found that many teachers seriously lack pedagogic skills regarding supporting individual differences in students (Kent, 2004; Laine & Otto, 2000). Insufficient pedagogical skills may be attributed to current teacher education and development practices for both pre-service and in-service teachers (Kent, 2004).

The previous literature references emphasize that continuous professional development is crucial for teachers who work in an environment of school curriculum changes. Adequate time should be made available for teachers to study and plan if they are to effectively and successfully implement the curriculum (Laine & Otto, 2000). Literature indicates that most school districts in America usually provided too little time for professional development (Kent, 2004). The outcome of such a situation is that teachers may not be in a position to pass sound judgment regarding learners' needs.

The research described in this article is approached from the perspective of a teacher's professional development. According to Villegas-Reimers (2003, p. 11), professional development is broadly defined as "the development of a person in his or her professional role." More specifically, teacher development is explained as "the professional growth which a teacher achieves as a result of gaining increased experience and examining his or her own teaching systematically" (Gatthorn in Villegas-Reimers, 2003, p. 11). According to Villegas-Reimers (2003), professional development includes formal experiences such as reading professional publications, watching TV documentaries related to an academic discipline, and attending cluster meeting workshops. It is broader than career development, staff development, or in-service training, and it includes a long-term development process.

Teacher training is pivotal to the success of curriculum change (Brown, Sithole, & Hofmeyr, 2000). Thus, the challenge to the system is to help teachers to become change agents and thereby enable them to lend impetus to transformation (Brown et al., 2000; DoE, 2006) through creative approaches (Castellano & Datnow, 2000; Kent, 2004). Many studies have shown that teacher competence in pedagogic and content knowledge is crucial for student achievement (Borko, Elliott, McIver, & Wolf, 2000; Darling-Hammond, 2000; Kent, 2004; Pikulski, 2000; Rivers & Sanders, 1996). In an attempt to develop teachers professionally, the DoE in South Africa proposed new professional qualifications for teachers, namely the four-year Bachelor of Education (BEd) degree, with a senior certificate, that is matric plus four years' qualification as prerequisite; and a Postgraduate Certificate in Education (PGCE) (Aluko, 2009). However, in reality in South Africa about 40% of practicing teachers are either unqualified or underqualified (DoE, 2009) and hold outdated teachers' diplomas, such as the Primary Teachers Diploma, the Senior Primary Diploma in Teaching, the Junior Primary Teachers Diploma, or the Senior Teachers Diploma (Welch, 2009). According to a survey undertaken by the Human Science Research Council (HSRC), only about 18% of currently practicing teachers are professionally qualified.

Technology Learning Area (TLA) and Teacher Development

The introduction of technology education has triggered an urgent and fervent need for in-service technology teacher training as part of teachers' professional development. This need was exacerbated by the fact that technology education was introduced as a relative newcomer at the inception of C2005 (Gumbo, 2003; Maluleka, Wilkinson, & Gumbo, 2006). There were no trained or qualified technology teachers at this stage. When technology education was rolled out with C2005 in 1998, teachers, qualified in other subject fields, were asked by the DoE to volunteer to teach technology. They thus started teaching technology with a very limited pedagogical content knowledge background. Similar developments were reported internationally. Reference can be made to China, where teachers "floor-crossed" from other disciplines – with different knowledge backgrounds – into technology education (Feng & Siu, 2009). Feng and Siu (2009) view in-service teacher education, based on the China experience, as a crucial factor in technology curriculum development.

As part of a formal two-year qualification to address the technology teacher training backlog, the DoE decided on the ACE qualification to fast-track teacher training, particularly as an in-service training course. The ACE program enables teachers to upgrade from a Matric + 3 (matric plus three years' qualification) to an M + 4. The ACE furthermore provides the option for practicing teachers to either qualify in a new subject learning area or to specialize in a subject/learning area that they are currently teaching (DoE, 2000). The admission requirements for entry into the ACE program include professional qualification. This qualification may be either a three-year teachers' diploma, or a BEd degree (Aluko, 2009). When the program it completed, it is envisaged that teachers will be highly competent in terms of knowledge, skills, and didactics relevant to the subject. This is in keeping with the principles of the National Policy Framework for Teacher Education and Development in South Africa, which states that "a teacher should be a specialist in a particular learning area, subject or phase" (DoE, 2006, p. 5).

Since 2002, in-service training workshops sponsored by the DoE for Higher Education Institutions have been held for teachers during school holidays and on Saturdays. In this regard, Potgieter (2004) accounted for some 137 teachers who participated in workshops that he facilitated, and some 950 teachers who enrolled with the University of South Africa in 2002 for the ACE program. However, despite these initiatives, according to Ndahi and Ritz (2003), the supply of technology teachers is still minimal and should continue to receive attention. The DoE (2006, p. 16) furthermore stated that "both conceptual and content knowledge and pedagogical knowledge are necessary for effective teaching."

The nature of technology is more of project based and problem driven. This means that students design and make projects to solve identified problems with "structures," that is, electrical and mechanical systems. In line with this nature of technology, the ACE training program reported in this article covered the following topics: (1) technological processes and skills, which includes investigate, design, make, evaluate, and communicate. It is about designing, making, and evaluating technology prototypes or artifacts to solve technological problems while incorporating a range of other technological processes; (2) technological concepts and content knowledge, which includes structures, material processing, electrical/electronic control systems, and mechanical systems; (3) indigenous technology, which is about the impact and biases that technology has on society and the environment. These topics were integrated in the practicals that teachers conducted within "structures," electrical and mechanical systems.

Limitations

The research under discussion was designed as an exploratory study, and a quantitative research approach was used to this effect. A mixed-model approach, in which quantitative results (e.g., interviews) complement quantitative deductions, could have enriched the findings. Time and funding was however a restricting factor in this study; therefore, it was argued that once the impact of technology training had been verified, future studies should incorporate additional aspects, such as the length of the training presented, countrywide representation of respondents, and qualitative methods to strengthen research findings.

Research Design

The formal hypothesis of the research question on the impact that the Technology- ACE training program has on technology teaching knowledge of practicing teachers can be formulated as follows: There is no statistically significant difference between the pre- and post-knowledge and understanding survey scores of practicing teachers who completed the ACE professional development program in technology education. The research environment in which the research was conducted that is reported on in this article is briefly discussed in this section.

The first two authors were involved as facilitators in an ACE-Technology training program offered during 2008 and 2009. The program was a collaborative project between the Tswane University of Technology and the Vaal-Triangle University of Technology, and it trained senior phase technology teachers of the Gauteng (Sebokeng, Johannesburg North, Soweto and Tswane West Districts) and Mpumalanga Provinces (Bushbuckridge District). The authors were keen to assess the impact of subject-specific (technology education/TLA) training on technology teachers' knowledge and understanding of the subject of technology education. Hence, the researchers integrated their training with the research project under discussion and undertook a quantitative survey design study.

A questionnaire was designed and administered to technology teachers at the beginning of the ACE-Technology training program in 2008 to determine the status of teachers' technological knowledge and understanding. The same questionnaire was administered to the same teachers when they completed the program in 2009 to determine the impact that the training had had on the teachers' perceptions of their technological knowledge and understanding. The questionnaire included 14 questionnaire statements on teachers' perception of their knowledge and understanding of technology education subject matter and interpretation (see Tables 2 and 3). The statements were scored according to a five-point Likert agreement rating scale. Questions on biographical attributes included training background, qualifications, and qualifying institutions, as well as present and past teaching experience.

Ethical research aspects were addressed by acquiring permission to conduct the research from the DoE and participating parties. ACE organizing officials and senior DoE staff who visited the training sites were approached for ethical clearance. Survey participation was voluntary, and the purpose of the study was explained to the participating teachers.

The target population of the study was practicing technology teachers and the population was sampled purposively since several logistical problems initially compromised random sampling: teachers interpreted the registration procedure incorrectly due to poor communication by the DoE; and other teachers enrolled late because school managements granted permission at a late stage; in other cases teachers attended classes infrequently; or teachers who had been selected to attend did not attend and some teachers switched between the ACE specialization fields of mathematics, science, and technology. As a result, 304 teachers who were conveniently available participated in the questionnaire survey.

Analysis Strategy

One-way frequency distributions on respondents' biographical attributes were calculated to provide a descriptive background of the sampled population and to verify the representativeness of the sample in terms of target population attributes. These frequency distributions were furthermore used to determine whether biographical attributes could be further investigated for their effect on teachers' technology knowledge acquisition – over and above the effect that the ACE-Technology education training program had on the acquisition and understanding of technology knowledge.

Composite frequency tables on the knowledge and understanding perception rating statements (14 statements), which respondents rated before and after the completing the ACE- Technology education training were also calculated to provide a general overview of respondents' perceived knowledge and understanding prior to and after the ACE training (Table 2). The difference between pre- and post-ACE technology knowledge and understanding perception scores were also calculated for each respondent and statement. The analysis strategy argued that if training did not affect the perception of teachers' technological knowledge and understanding, perception ratings prior to and after ACE-Technology training would be more or less the same. This no-effect assumption would imply that the difference between pre- and post-training scores would be close to zero. A nonparametric Wilcoxon- signed rank test was conducted on all difference ratings, combined over all the questionnaire statements, to test the hypothesis that the general mean difference rating score was zero. Separate tests were also calculated on the 14 sets of difference scores for each knowledge statement. These tests were conducted separately to assess whether teachers perceived to have significantly improved their knowledge and understanding on each aspect of technology tutoring that the questionnaire probed.

Once the issue of the impact of ACE-Technology training had been validated, the analysis strategy investigated the effect that biographical attributes – such as previous technology tutoring experience and previous technology training, could possibly have had on the expected increase in technology knowledge and understanding (over and above the effect of ACE-Technology training on technology knowledge and understanding). Nonparametric analysis of variance (Kruskal-Wallis one-way analysis of variance) was used to investigate this aspect of the research. The analysis strategy was duly followed and analysis results are presented in the next section.

Analysis Results and Interpretation

Biographical attributes of the sample

Table 1 presents the frequency distributions of the biographical variables probed in the questionnaire.

These distributions describe the sample as teachers of whom approximately the same proportion was selected/or attended the ACE technology education program voluntarily (50.34% and 48.65%); and the same proportion had no/had previous formal training in technology teaching (58.75% and 41.25%). The figures show that previous training was most commonly gained from week-long workshops (51%) and that previously acquired technology education qualifications mostly consisted of an attendance certificate (58.14%). Approximately half of the respondents had taught technology previously, and 73% of teachers were currently teaching technology.

Table 1
One-way frequency distributions of respondents' biographical attributes

How were you selected? (missing = 8)					Qualifying institution (missing = 217)				
	f_i	%	Cum f_i	Cum. %		f_i	%	Cum f_i	Cum. %
DoE inst. urban	92	31.08	92	31.08	Secondary Sch	13	14.94	13	14.94
School sent me	57	19.26	149	50.34	Tech/College	17	19.54	30	34.48
I volunteered	144	48.65	293	98.99	University	31	35.63	61	70.11
Other	3	1.01	296	100.00	In- job training	22	25.29	83	95.40
					Private Inst	4	4.60	87	100.00
Training background in Technology education? (missing = 1					Taught technology prior to ACE? (missing = 5)				
Yes	125	41.25	125	41.25	Yes	160	53.51	160	53.51
No	178	58.75	303	100.00	No	139	46.49	299	100.00
Type of training (missing 171)					Grade taught previously (missing 226)				
Workshop	105	78.95	105	78.95	Grade 8	78	100.0	78	100.00
Tech Ed qual.	22	16.54	127	95.49					
Other	6	4.51	133	100.00					
Workshop duration (missing = 187)					Currently teaching technology (missing = 4)				
One day	32	27.35	32	27.35	Yes	219	73.00	219	73.00
Two days	14	11.97	46	39.32	No	81	27.00	300	100.00
Three days	11	9.40	57	48.72					
One week/more	60	51.28	117	100.00					
Type of qualification (missing = 218)					Grade currently teaching (missing = 216)				
Attendance cert.	50	58.14	50	58.14	Grade 8	86	97.73	86	97.73
Diploma	28	32.56	78	90.70	Grade 12	2	2.27	88	100.00
1st Degree	6	6.98	84	97.67					
H/ M/ Doctorate	2	2.33	86	100.00					

The deduction could thus be made that the sample appropriately represented the target population of the research, namely, practicing technology teachers with limited formal teaching qualification.

Once the adequacy of the sample had been verified, the authors' attention was turned first to an exploratory overview of technology knowledge and understanding perception trends and next to a formal validation of these observed improvement trends. A summary of the respective analysis results is presented in Tables 2 and 3.

Perceptions regarding technology knowledge and understanding

In Table 2, the total frequency distribution row before onset of the ACE program indicates that the majority of perception responses fell in the *no-experience to limited experience* categories (61%). If the perception rating scale of no experience to extensive experience is interpreted as *"a substantial lack of knowledge"* to *"substantial knowledge or confidence,"* then the deduction can be made that respondents seemed to lack the general academic knowledge and understanding to teach technology before they started the program.

On the other hand, when the participants completed the program the total row frequency distribution indicates that respondents in general felt more relaxed about their academic knowledge and understanding of technology once they had undergone ACE- Technology training, since the majority of responses now fell in the *moderate* to the *more than average* experience perception categories (91%). This shift seems to indicate that respondents felt more confident about their technology knowledge and insight once the ACE-Technology training program had been completed.

Table 2
Frequency distributions of 304 participants to the 14 knowledge and insight perception rating statements of the technology survey questionnaire scored prior to and on completion of the ACE-Technology training program

	No experience		Limited experience		Moderate experience		Above average experience		Extensive experience		Totals	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1. Meaning of technology	64	3	108	10	87	143	38	134	6	6	303	296
2. Meaning of tech. Education	86	3	108	12	72	140	31	133	3	6	300	294
3. Learning outcomes, ass. stds	89	3	68	11	83	101	58	172	3	7	301	294
4. Grasp/apply design process	106	4	71	9	76	125	46	152	5	6	304	296
5. Identify problems/ needs/wants	87	3	94	16	74	132	39	137	3	2	297	290
6. Structures/strengthening techniques	77	3	77	11	84	122	51	153	3	5	292	294
7. Priorities, selecting materials	75	3	100	16	78	119	46	152	2	3	301	293
8. Systems and control	90	5	99	26	72	144	27	112	0	4	288	291
9. Design, completing projects	96	4	88	22	84	148	28	116	3	4	299	294
10. Identify and apply resources	78	3	90	21	91	132	34	134	2	3	295	293
11. Tech. lesson planning	87	3	91	21	88	137	30	127	1	4	297	292
12. Tech. methods and strategies	97	5	103	20	66	151	32	114	1	4	299	294
13. Tech. assessment	104	5	96	26	71	154	27	106	1	3	299	294
14. Implement NCS Tech Grade 8	99	4	92	27	77	146	31	114	2	1	301	292
TOTAL	1235	51	1285	248	1103	1894	518	1856	35	58	4176	4107
Percentage of pre-/post-totals	30%	1.4%	31%	6%	26%	46%	13%	45%	.1%	1.6%		
Frequency Missing = 80 (pre); 149 (post)												

Table 3
Wilcoxon signed-rank test results on the overall pre- post-difference dataset and on the fourteen subsets of pre-post-differences for each of the questionnaire statements to test the hypotheses, of location: $Mu_0 = 0$

Signed-rank test to test the null hypothesis of no overall improvement in knowledge once ACE-technology training is completed *($H_0 : Mu_0 = 0$)*

Knowledge aspect	*N*	S-statistic Signed-rank test	Probability associated *S*-Statistic	Mean (std. dev.)	Skew -ness	Kurtosis
Signed rank test to test the null hypothesis of no overall improvement in knowledge once ACE-technology training is completed *($H_0 : Mu_0 = 0$)*						
Overall knowledge improvement#	4047	2195144.00	< 0.0001***	1.19 (1.00)	0.05	-0.63
The signed rank sum test results on knowledge statements (14) assessed in the questionnaire						
Meaning of technology	296	11420.00	< 0.0001***	1.08 (0.93)	0.14	-0.29
Meaning of technology education	290	12472.00	< 0.0001***	1.27 (0.98)	-0.10	-0.48
Learning outcome, assessment standards	291	9401.00	< 0.0001***	1.21 (1.12)	0.12	-0.55
Grasp and apply design process	296	11301.50	< 0.0001***	1.28 (1.12)	-0.01	-0.86
Identify problems, needs and wants	287	11218.00	< 0.0001***	1.20 (1.01)	-0.01	-0.78
Structures, strengthening techniques	283	10027.50	< 0.0001***	1.14 (1.00)	0.05	-0.84
Priorities, selecting material	291	11038.50	< 0.0001***	1.17 (1.02)	0.11	-0.80
Systems and control	278	11542.50	< 0.0001***	1.19 (0.90)	0.13	-0.54
Design, completion of projects	290	10953.00	< 0.0001***	1.18 (0.99)	0.01	-0.62
Identify and apply resources	286	11065.50	< 0.0001***	1.13 (0.94)	0.06	-0.65
Lesson planning, technology	287	11385.00	< 0.0001***	1.18 (0.99)	0.14	-0.68
Technology methods and strategies	290	11489.50	< 0.0001***	1.22 (1.00)	-0.03	-0.60
Implementation tech assessment	291	12501.50	< 0.0001***	1.22 (0.95)	-0.05	-0.64
Grasp, implement Grd R9 NCS Tech	291	11863.50	< 0.0001***	1.15 (0.97)	-0.01	-0.59

#: The differences for the overall knowledge improvement variable were calculated by subtracting scores rated on program completion from ratings scores rated prior to course commencement for each of the 14 subquestions for each respondent. The total number of responses considered was therefore 14 x 304 = 4256.

For the individual rank tests only data of respondents that completed the same question on both questionnaires could be included in the various analyses, therefore varying totals are reported.

Nonparametric Wilcoxon Signed-Rank Tests

These initial indications of technology competency shifts were further explored and statistically validated by means of nonparametric Wilxocon signed-rank tests. The tests were conducted on the combined difference data set as well as on the 14 individual subsets of pre- post-difference scores for each of the 14 questionnaire statements for all respondents. The null hypotheses evaluated in all instances state that the ACE program did not statistically significantly improve technology competencies in any respect (14 competency aspects and a general trend), as opposed to the alternative hypotheses of a statistically significant effect of ACE-Technology intervention on technology competency. Table 3 summarizes the results of the Wilxocon tests.

Highly significant Chi-square test statistics were associated with all Wilcoxon signed- rank tests (column 4 Table 3). The tests therefore verify initial indications of positive shifts in perceived technology competency. The general test in Table 3 verified that teachers perceived ACE-Technology programs to statistically significantly improve their technology teaching competencies; more specifically, teachers perceived that all (14) aspects of their t echnology knowledge and understanding that were probed in the questionnaire were statistically significantly enriched by the ACE-Technology intervention.

Nonparametric Kruskal-Wallis Analysis of Variance

The results, derived from Tables 2 and 3, thus answered the main concern of the study: ACE-Technology intervention had a positive impact on teachers' perceptions of their technology teaching competencies. To enrich these findings, the researchers also investigated the effect that other factors might have played a role in teachers' perceived improved technology teaching capabilities. Separate nonparametric Kruskal-Wallis analyses of variance were conducted on the overall set of differences between pre- and post-rating scores of respondents to evaluate how respondents' perceptions of their improved technology training competency were affected by the following:

- Previous or no previous exposure to technology training,
- The type of previous technology training exposure,
- The type of previous technology training,
- The type of technology qualification previously obtained,
- The institute at which the previous qualification was obtained,
- The province where the respondent was taught, and
- Previous experience teaching technology (prior to the ACE-Technology program).

The results of these analyses are summarized in Table 4, and the factors investigated are listed in column 1 of Table 4.

The analysis results identified the following biographical factors as statistically significant additional role players (over and above ACE-Technology intervention) affecting perceived general positive change in teachers' technology knowledge and understanding, namely:

i. **Previous exposure to technology training:** Teachers who had had previous exposure to technology training perceived their level of increased technology knowledge and understanding to be statistically significantly less than teachers who had no previous exposure to technology training prior to the ACE-Technology program. (The two mean differences of 0.95 and 1.36 proved to differ statistically significantly from each other).

ii. **Type of previous technology training exposure:** If previous training exposure consisted of a technology education qualification, respondents experienced significantly less change in their levels of technology knowledge and understanding when compared with technology training exposure at workshops or other modes of training exposure. (Table 4 indicates the statistically significant difference between the mean difference of 0.58 and the mean differences of 1.06 and 1.53).

iii. **Previously obtained technology qualification:** A statistically significantly greater change in knowledge perception was experienced by respondents who had attendance certificates in technology, diplomas, or a first degree in technology teaching than those with an Honors or second degree qualification (mean differences of 0.95; 0.75 and 0.75, as opposed to 0.29).

iv. Institution from which previous qualification was obtained: The respondents who obtained their qualifications from a private institution experienced significantly less change in their level of technology knowledge and understanding perception (mean difference of 0.31) than did those who had attained their qualification at a secondary school (0.97), at a college/technikon (0.83), at a university (0.81), or "on the job" (1.10).

v. Province where respondents taught: Teachers from Mpumalanga perceived a statistically significant greater increase in knowledge and understanding perception level than teachers from Gauteng.

vi. Previous experience in technology teaching: The respondents who had not previously taught technology perceived a statistically significant greater change in their level of technology knowledge and understanding than did those who had taught technology prior to the ACE-Technology program.

Discussion of Findings

The study in this paper aimed to assess the effect that the ACE-Technology training programs had on technology teachers' professional development regarding their knowledge and understanding of technology. The findings revealed that teachers overwhelmingly benefited from the training in terms of their knowledge and understanding of technology. This held true for the overall perception of improved technology knowledge and understanding competency once ACE-Technology training had been completed, as well as for the 14 specific aspects of technology knowledge and understanding

Table 4

Non-parametric Kruskal-Wallis one-way analyses of variance on pre- post-score differences to determine the significance of the role of other biographical factors on teachers' perception of improved technology teaching competencies in addition to the established effect of ACE-Technology program intervention on teaching competencies

	N Obs	Mean	Std Dev	Maximum	Minimum	*N*
Previous technology training Kruskal-Wallis Chi-sq statistic = -13.3835, probability(chi-sq statistic-value) < 0.0001***						
Yes	1750	0.9487	0.9239	3.0000	-1.0000	1656
No	2492	1.3610	1.0090	4.0000	-3.0000	2377
Type of previous technology training exposure Kruskal-Wallis Chi-sq statistic = 93.40, probability(chi-sq statistic-value) = 0.0001***						
Workshop training	1470	1.0651	0.9206	3.0000	-1.0000	1397
Tech education qualifications	308	0.5776	0.8838	3.0000	-1.0000	277
Other training exposure	84	1.5256	0.9359	3.0000	0.0000	78
Type of technology qualification obtained Kruskal-Wallis Chi-sq statistic = 22.76, probability(chi-sq statistic-value) < 0.0001***						
Attendance certificate	700	0.9451	0.9745	3.0000	-1.0000	656
Diploma	392	0.7521	0.8203	3.0000	-1.0000	359
1st Degree	84	0.7470	1.2282	3.0000	-1.0000	83
Hons/MEd/DEd	28	0.2857	0.6587	2.0000	-1.0000	28
Institute where the previous qualification was obtained Kruskal-Wallis Chi-sq statistic = 44.59, probability(chi-sq statistic-value) < 0.0001***						
Secondary school	182	0.9670	0.9337	3.0000	-1.0000	182
Technikon/College	238	0.8316	0.7627	2.0000	-1.0000	196
University	434	0.8099	1.0193	3.0000	-1.0000	426
In-job training	308	1.0976	0.9739	3.0000	-1.0000	287
Private institution	56	0.3061	0.6832	3.0000	-1.0000	49
Province where respondent taught Kruskal-Wallis Chi-sq statistic = 106.70, probability(chi-sq statistic-value) < 0.0001***						
Province						
Gauteng	2464	1.0498	0.9916	4.0000	-3.0000	2330
Mpumalanga	1750	1.3743	0.9589	3.0000	-1.0000	1691
Previous teaching experience in technology Kruskal-Wallis Chi-sq statistic = 81.78, probability(chi-sq statistic-value) < 0.0001***						
Yes	2240	1.0669	0.9397	3.0000	-1.0000	2124
No	1946	1.3479	1.0406	4.0000	-3.0000	1854

probed in the research. The initial indications of improved competency indicated in the exploratory frequency analyses were neatly statistically confirmed in the advanced statistical analysis.

Other contributing factors, expressed as biographical attributes of teachers, presented some noteworthy perspectives on the findings. Teachers who had had no previous exposure to technology education training perceived that they benefited more from the ACE-Technology program than did their peers, who had previous exposure to technology training (confirmed in deduction (i) of the *analysis results and interpretation* section). This finding may be related to these teachers' heightened determination to learn more from the training to fill their technology knowledge training gap. These findings serve to strengthen the opinion of research by the DoE (2006), Taylor and Vinjevold (1999), Jansen and Christie (1999) and Aluko (2009), who concluded that the training of many teachers (underqualified and unqualified) is still incomplete. Furthermore, results indicated that (deduction (ii), in the *analysis results and interpretation* section) teachers who had received previous technology training at colleges perceived that they benefited less from the ACE-Technology training than did those who had previous technology training exposure through workshops. The longer institutionally based technology training for the college teachers might provide the reason why these teachers perceived to have benefited less from the ACE-Technology training program: they most probably gained more knowledge and understanding of technology during their college training. An interesting finding that was not expected in the research (deduction (v), in the *analysis results and interpretation* section), is that the Mpumalanga respondents experienced a significantly greater positive change in technological knowledge post-ACE-Technology training compared with that of their Gauteng Province colleagues. This may be attributed to their higher level of commitment to acquire technology teaching capabilities because of the "the rural environment" where they work and the assumption that their rural setting is "technologically poor." Deduction (iii) in the *analysis results and interpretation* section furthermore indicated that teachers who had attendance certificates in technology perceived their acquired technology competency to have improved significantly more on ACE-Technology completion than did teachers with an Honors or second degree qualification prior to ACE-Technology training. Teachers with an Honors degree were most probably more knowledgeable at the onset of ACE-Technology training. Deduction (vi) of the *analysis results and deductions* section also indicated that teachers who had not previously taught technology perceived to have benefited significantly more from the ACE-Technology training than did those who had taught technology previously. The latter group most probably had ample exposure to technology prior to ACE-Technology training, and they could therefore identify with what the ACE-Technology training covered. These findings confirm that the benefit that these categories of teachers derived from the training based on their biographical attributes is in keeping with DoE's (2006) intention with ACE programs – for teachers to become specialists in their subject areas.

Recommendations

Technology teacher training should be preceded by profiling teachers and analyzing needs so that strategic decisions can be made to vary the depth and nature of the training based on the profile and specific needs; otherwise, the training may not be beneficial to all. Teachers without any training background in technology should preferably receive intensive training in all content knowledge and pedagogical areas. For those with some training background, only specific gaps as identified in their needs survey should be addressed in the training. Furthermore, because a quantitative research approach (as was followed in the current research) might have presented as a limiting factor in knowledge acquisition on the dynamics of perceived benefits to be gained from ACE-Technology training, researchers should consider mixed-methods approaches for the assessment of the impact of training on technology teachers in future studies. Such an approach will enable triangulazation. The current exploratory study was also restricted to only two provinces in South Africa. In the future, a study of this nature should be extended to other provinces to be able to generalize to South Africa as a whole.

Conclusion.

This paper reported the findings of the study that inquired into the effect of ACE-Technology training of teachers regarding their knowledge and understanding of technology. In terms of the research question and the hypothesis that was stated, the main finding of the study is that the ACE training in technology education enhanced teachers' knowledge and understanding of technology. This is an important finding considering that technology education is a relatively new learning area/subject and that there is dire need for training teachers to offer the same to learners. Furthermore, the training of teachers in the field should be seen to make a difference in their knowledge of technology and the methodologies of presenting it to the learners. It is hoped that teachers who underwent this training are now serving their learners in schools by implementing what they have acquired.

Dr Mishack Gumbo is a senior lecturer in the Science and Technology Education Department, College of Education at the University of South Africa.

Dr. Moses Makgato is an associate professor in the Department of Educational Studies at Tshwane University of Technology, South Africa.

Heléne Müller is a senior research support consultant in the Department of Interdisciplinary Research, College of Graduate Studies at the University of South Africa.

References

Aluko, R. F. (2009). The impact of an Advanced Certificate in Education (ACE) Program on the professional practice of graduates. *International Review of Research in Open and Distance learning*, 10(4), 1-15.

Borko, H., Elliot, R. L., McIver, M. C., & Wolf, S. A. (2000). "That dog won't hunt": Exemplary\ school change efforts within the Kentucky reform. *American Educational Research Journal,* 37(2), 349-393.

Brown, C., Sithole, V., & Hofmeyr, R. (2000). South Africa: Teacher training in the sky. *TechKnowlogia*, 53-54.

Castellano, M., & Datnow, A. (2000). Teachers' responses to success for all: How beliefs, experiences, and adaptations shape implementation. *American Educational Research Journal*, 37 (3), 775-799.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. *Education Policy Analysis Archives*, 8 (1), 1-49.

Department of Education. [DoE]. (2000). Norms and Standards for Educators. Pretoria: Government Printers.

Department of Education. [DoE]. (2003). Revised National Curriculum. Pretoria: Government Printers.

Department of Education. [DoE]. (2005). Revised National Curriculum. Pretoria: Government Printers.

Department of Education. [DoE]. (2006). The national policy framework for teacher education and development in South Africa: More teachers; better teachers. Pretoria: Government Printers.

Department of Education. [DoE]. (2009). Teacher Qualification Survey: Draft report prepared by Human Sciences Research Council for Department of Education.

Department of Education. [DoE]. (2010). Curriculum and Assessment Policy Statement (draft document). Pretoria: Government Printers.

Feng ,W., & Siu, K. W. M. (2009). Professional development for technology teachers in Mainland China and Hong Kong: Bridging theory and practice. A paper presented at the PATT22 conference held between 24-28 in Delfti.

Gumbo, M. T. (2003). Indigenous technologies: Implications for a technology education curriculum. (Unpublished PhD thesis). Pretoria: Vista University.

Jansen, J., & Christie, P. (Eds). (1999). Changing curriculum studies on OBE in South Africa. Pretoria: Juta & Co Ltd.

Kent, A. M. (2004). Improving teacher quality through professional development. Retrieved from http://findarticles.com/p/articles/mi_qa3673/is_3_124/ai_n29092860.

Laine, S. W. M., & Otto, C. (2000). Professional development in education and the private sector: Following the leaders. Oak Brook, IL: North Central Regional Educational Laboratory.

Maluleka. K., Wilkinson. A., & Gumbo. M. (2006). The relevance of indigenous technology in Curriculum 2005/RNCS with special reference to the Technology Learning Area. S*outh African Journal of Education*, 26(4), 501-513.

Ndahi, H. B., & Rit, J. M. (2003). Technology education teacher demand, 2002-2005. *The Technology Teacher*, 27-31.

Ono, Y., & Ferreira, J. (2010). A case study of continuing teacher professional development through lesson study in *South Africa. South African Journal of Education*, 30, 59-74.

Pikulski, J. J. (2000). Increasing reading achievement through effective reading instruction (Tech.Rep.No. 19716). Newark, DE: University of Delaware, School of Education.

Potgieter, C. (2004). The impact of technology education, as a new learning area, on in-service teacher education in South Africa. *International Journal of Technology and Design Education*, 14, 205-218.

Rivers, J. C., & Sanders, W. L. (1996). Cumulative and residual effects of teachers on future student academic achievement. Knoxville: University of Tennessee Value-Added Research and Assessment Center.

Taylor, N., & Vinjevold, P. (1999). Getting learning right: Report of the president's education initiative project. Johannesburg: The Joint Education Trust.

Villegas-Reimer, E. (2003). Teacher professional development: An international review of the literature. Paris: International Institute for Educational Planning.

Welch, T. (2009). Teacher education qualifications: Contribution from Tessa Welch to working paper for teacher development summit – 27 May 2009.

Voices from the Past: Messages for a STEM Future

Todd R. Kelley

ABSTRACT

The current emphasis in K-12 education on science, technology, engineering, and mathematics (STEM) (Douglas, Iversen, & Kalyandurg, 2004; Sanders, 2009) creates many ways to partner engineering education with these fields. Therefore, it is appropriate to examine the commonalities these fields have with engineering education. Though much of the science education and mathematics education history is understood, technology education's history is not common knowledge, and as a result misconceptions abound (Daugherty & Wicklein, 1993 Wicklein, 2008). Technology education's longstanding history in problem- and project-based learning, design- and engineering-related pedagogical approach is over a century old and grounded in theories of Comenius, Rousseau, Pestalozzi, Froebel, Herbart, Sheldon, and Dewey (Dewey, 1915; Foster, 1995, 1997; Herschbach, 2009; Kirkwood, 1994). The brief review of technology education's history will reveal an almost eerie parallel to the current engineering education and STEM education movements.

Key Words: technology education, K-12 STEM education, project-based Instruction, design-based instruction

Introduction

Although other authors have visited various historical milestones in technology education origins such as manual arts, manual training, industrial arts, industrial technology (Bonser, 1926; Foster, 1995, 1997; Herschbach, 2009; Scott & Sarkees-Wircenski, 2004), this article will highlight some less explored milestones within technical education that provide opportunity for reflection on the current position held by technology education regarding the STEM paradigm. Some milestones featured here cross paths with early American engineering programs that emphasized project-based instruction while other milestones promote design-based instruction within technology education and general K-12 education. Finally, the focus of this historical journey will conclude with recent milestones that integrate core subjects with technology education. Recent approaches to K-12 STEM education appear to mix of these various pedagogical approaches to integrate the four subjects (science, technology, engineering, and mathematics); thus, this provides the rationale to revisit these voices of the past to speculate what these milestones might indicate for the success of a the T in STEM. Figure 1 illustrates both the milestones that are featured in this article and a general progression that led to the current STEM movement. Although many technology education milestones are not featured in this article, those selected here provide insight not only for technology education but also for engineering education, the two often-neglected members of the greater STEM community.

Early Design-Based Instruction

American's early educational movement in the field better known today as technology education was heavily influenced by European education pioneers (Herschbach, 2009). The father of the modern kindergarten movement, Friedrich Froebel, first studied under Johann Heinrich Pestalozzi. Both educational reformers believed heavily in educating children in a full range of real-life activities and using a hands-on approach to teaching. Pestalozzi focused on the object lesson, that is, using objects for concrete observations, which was later brought to the

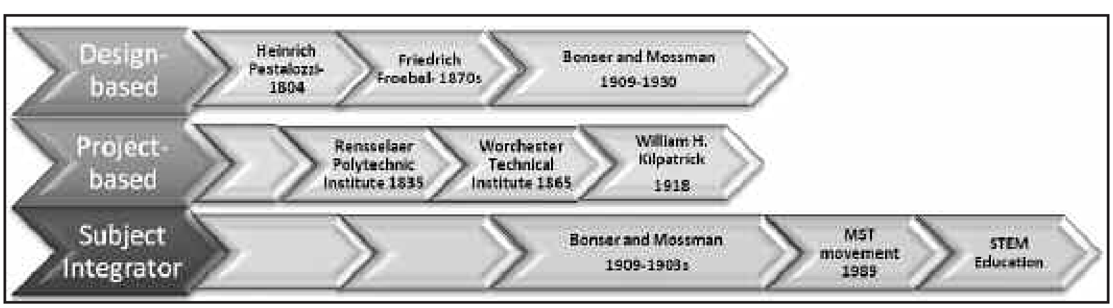

Figure 1. Technology and Engineering Education Milestones Leading to a STEM future.

United States by Edward Austin Sheldon (Foster, 1995). Pestalozzi began this work with orphans in Switzerland in 1804. Another pedagogical hands-on approach used by Pestalozzi was combining sketch work as a way to teach children how to learn and write letters from the alphabet. Froebel studied Pestalozzi's methodologies and developed his own theoretical framework on the three realms, which included forms of nature (or life), forms of knowledge (or science), and forms of beauty (or art). These realms were introduced to children via short sessions of guided play with building blocks, mosaic toys, and traditional crafts. Children were taught to look for the mathematical equations in these objects.

> The ultimate lesson of kindergarten was straightforward: the forms of the world, mathematics and art are equivalent and interchangeable. A chair made of eight cubes might become the number eight, then a pinwheel design, then a bed and so on. (Brosterman, 1997, p. 111)

Frobel actually marketed children's building kits (e.g., manufactured by E. Steiger & Company and A. N. Myers & Company) in the 1860s-1870s as a way to study design and geometry. These kits included stick and cork geometric form building kits, carefully proportioned maple wood building blocks, colored cardboard triangles, and even child-size grid tables as a work surface to guide geometric pattern construction (Brosterman, 1997).

Famous American architect, Frank Lloyd Wright was given these Frobel toys as a child. He credited his success in architecture with his early childhood experiences using the grid table, cardboard shapes, and the maple wood blocks. He believed the Frobel gifts were foundational to developing his abilities to design later in life (Brosterman, 1997; Coleman, 2008). As engineering education and other STEM efforts seek to teach young learners about design and engineering, these STEM stakeholders should consider revising Frobel's methodologies as tools to teach design. Consider recent engineering education efforts to teach children about engineering using toys such as LEGO® building blocks (Capozzoli & Rogers, 1996; Connolly, Wendell, Wright, Jarvin, & Rogers, 2010; Erwin, Cyr, & Rogers, 2000). Frobel is just one of many unlikely educational pioneers who influenced the field of technology education; he is considered an unlikely influencer because his contribution is neither technical nor vocational, but it is design and aesthetically focused.

Technology Education for All

Other pioneers in the history of technology education also focused on the design and aesthetics of the study of technology. Frederic Bonser and Lois Coffey Mossman had a profound influence on the early beginnings of technology education, and much of their work focused on the elementary grades. Bonser and Mossman believe that all children should receive manual training and industrial education, and the purpose was social reform, not vocational education. Mossman is credited for being the first person to use the term Industrial Arts by 1909, when she proposed the combination of manual training, drawing, and home economics in elementary and middle grades (Foster, 1995). In addition to aligning the school's practical work with the traditional curriculum, Mossman emphasized the need for students to design their own projects. When learning about clothing, some students designed and made their own shirtwaists; when learning about shelter, students planned and drew houses ("On the ground floor," Coffey-Mossman, 1907, p. 123, in Foster, 1995). Although Bonser and Mossman provided many publications outlining their educational philosophies related to industrial arts (Bonser, 1911, 1926,1932; Bonser & Mossman, 1923; Mossman, 1924, 1929, 1938) much of their conception of industrial arts was lost when implemented in the classroom (Foster, 1995). This example should serve as a warning to STEM education leaders and educational policy makers that theory (educational philosophy) and practice (in-service teacher pedagogy) do not always mesh. If researchers of STEM fail to thoroughly investigate the complexities surrounding teacher practices that integrate STEM, the recent efforts to infuse STEM education into the classroom will be void.

Project-based Learning in Technology Education and Engineering

The early roots of technology education are closely intertwined with the development of the American engineering schools. Van Rensselaer, founder of Rensselaer Polytechnic Institute (RPI) in Troy, New York, along with Amos Eaton are credited for creating a university founded on teaching of the sciences through practical application, such as applying mechanical philosophy to the machinery of steamboats, mills, and factories. The practical applications of science at Rensselaer also included surveying land; calculating water pressures in locks, aqueducts, and dams; and designing and planting experimental gardens. These examples of pedagogical approaches to the sciences led to the founding of a department of Mathematical Arts at Rensselaer in 1835 “for the purpose of giving instruction in Engineering and Technology” (Bennett, 1926, p. 353). This is the first example of an American civil engineering school in the United States; four students graduated from RPI with civil engineering degrees in 1835, and before that time civil engineers were imported from France to build U.S. canals and bridges (Bennett, 1926).

Another important early American school of mechanical engineering that combined the theory and practice of engineering through scientific reasoning and shop experience was the Worcester Technical Institute in Worcester, Massachusetts, which was founded in 1865. Several donors, including John Boynton and Ichbod Washburn, two prominent Worcester industrialists, helped to make the Worchester Technical Institute a reality. It was Washburn, however, who added a unique element to the school curriculum; he wanted to teach vocational skills while Boynton wanted to teach science. A machine shop was donated to the institute to provide practical application to the science instruction. “Thus it came about that a new type of mechanical engineering course was made possible—a course which combined experience in a shop . . . and a theoretical course in applied science and engineering” (Bennett, 1926, p. 360). Bennett (1926) wrote that the shop was not for manual or industrial training but for educational purposes; the machine shop was considered as educational as a laboratory is to science. The work done in the machine shop was to be a substitute for an apprenticeship while the students simultaneously took mathematics, science, and engineering courses (Bennett, 1926). The news spread about the success of this educational approach and other universities around the country began to introduce shop work into their engineering programs (Scott & Sarkees-Wircenski, 2004). Although there were proponents of the practical application of mathematics, science, and engineering through hands-on manual education, many people during the decade from 1880-1890 had great opposition to manual training in K-12 classrooms, and as a result, the gap between academic subjects and hands-on activities began to widen (Bennett, 1926).

If one fast-forwards from Rensselaer’s 1835 era of practical application of engineering education to engineering education in the 21st century, one can make an eerie parallel. Authors Dym, Agogino, Eris, Frey, and Leifer (2005) explored the complexity of engineering design thinking and how design is best taught in engineering. Interestingly, these authors cited project-based learning (PBL) as the most favorable pedagogical approach for teaching design within engineering education. Moreover, Dym et al. (2005) suggested that the best context for PBL is first-year engineering cornerstone courses because it delivers a key element understood in cognitive science *transfer of learning* which “allows students to apply what was learned in new situations and to learn related information more quickly” (Bransford, Brown, & Cocking, 1999, p. 17). Dym et al. (2005) also indicated that PBL motivates students to learn upper level engineering sciences and helps with student retention in engineering schools. Brophy, Klein, Portsmore, and Rogers (2008) provided a comprehensive overview of engineering education curriculums and research efforts in P-12 classrooms within the United States, and once again PBL and other hands-on design-based instruction dominate the highlighted pedagogical approaches. The original founder of the project-based learning (PBL) concept was William Heard Kilpatrick. In September of 1918, Kilpatrick presented this theory of learning in an essay titled *The Project Method*, which emphasized "purposeful activity" to engage students in the learning process as they worked on a variety of projects. At the time, this new pedagogical approach was so popular that over 60,000 copies of the essay were published in pamphlet form (http://www.answers.com/topic/william-h-kilpatrick); later this information was published in book form entitled *Foundations of Method* (Kilpatrick, 1925). It was widely accepted in technology education (Industrial Arts) during that era.

> It was also an attractive idea that activity could serve as the center for correlating subject matter from a number of subject areas, such as English, math, science, and industrial arts. In this way, students could learn how to apply formal knowledge to the immediate concerns of their daily lives. (Herschbach, 2009, p. 33-34)

The current proposed approaches to K-12 STEM education and design- and project-based engineering education have origins in the works of both Kilpatrick and Rensselaer and the ideas of the Worcester Technical Institute. Some of the concepts of Rensselaer's engineering school of 1835 live on in today's modern engineering programs. Purdue's Neil Armstrong Hall of Engineering was completed in 2008. This new faculty includes multiple material testing and fabricating laboratories to provide hands-on design experiences. According to the Purdue University website, "Industry is demanding engineers who have traditional technical expertise along with design and building experience, often on industrial scale projects, and who can work in diverse teams" (see https://engineering.purdue.edu/Engr/AboutUs/Facilities/ArmstrongHall/Features/). These are several of examples of the history of technology education and engineering that illustrate that both fields are returning to their pedagogical roots by providing practical applications of design and engineering instruction. Although both fields often promote these methods as new innovations, the reality is that these approaches to education are well over a century old.

Technology Education is a Subject Integrator

There are many examples of subject integration within the history of technology education that can provide lessons to the STEM community. It is likely that current technology educators would be shocked to find so many examples of subject integration within the early forms of technology education (manual arts, manual training, and industrial arts). "Current efforts in technology education to integrate math, science, and technology also have an extensive heritage, although much of that heritage has either been neglected or ignored" (Pannabecker, 2004, p. 78). The industrial arts pioneer, Lois Coffey Mossman repeatedly emphasized in her writings that the integration of school subjects could be achieved through practical classroom activities. For example, she discussed the use of poems in a lesson in agriculture. Mossman emphasized the need to connect the study with arithmetic, geometry, reading, art, geography, nature study, physics, and botany (Coffey as cited in Foster, 1995). Although the roots of technology education as a subject integrator grow deep, what has occurred in the classroom provides little solid evidence of a widespread effort to use technology education as a vehicle to integrate subjects. Sanders (2009) indicated that technology education teachers like to boast about teaching science and mathematics but often fail to do so in practice. However, in the late 1990s, there were some efforts to reform the curriculum to conscientiously integrate math, science, and technology.

The MST Approach

One example of an educational approach to include technology education through a multidisciplinary approach to improve mathematics and science was the MST movement. Many educational leaders in the early 1990s recognized the need to improve American students' scores in science and mathematics. Documentation of the status of student achievement in math and science during this time can be found in reports such as *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* (National Research Council, 1989) and *Project 2061: Science for All Americans* (American Association for Advancement of Science, 1989). One approach considered to improve scores in these core subjects was to include technology education though design-based instruction as a way to provide a context for learning math and science. Many technology educators believed the MST approach as an outstanding opportunity for the field to be included with core subjects to provide exposure of technology education to all learners. Laporte and Sanders (1993) believed that the MST approach would improve the status of technology education; however, there were other leaders who wondered if technology education would become a stepchild in the 'marriage of math and science' (Foster, 1994; Gloeckner, 1991). Daugherty and Wicklein (1993) probed deeper to determine math, science, and technology teachers' perceptions of technology education. Their findings revealed that some misconceptions and poor perceptions of technology educators and the field technology education existed. Possible reasons for misconceptions about technology education were stated previously based upon the general public's exposure to industrial arts. Hansen (1995) in a study on teacher socialization within technology education provided another possible explanation. Hansen's study found that technology education teachers tend to congregate with peers within the field of technology education and as a result fail to connect with the greater learning community. Therefore, the technology educators have limited impact on how teachers in other content areas view and perceive the technology education field and local technology programs. This discovery within technology education should be considered as teacher professional development brings together STEM teachers to collaborate to integrate STEM disciplines within the classroom.

One of the best examples of the MST approach was the New York State Technology Education Network (NYSTEN), a project funded by the National Science Foundation. The goals of NYSTEN were to provide contemporary approaches of technology education, conduct educational research on technology education classrooms, and provide professional development opportunities and leadership opportunities to technology educators across New York State (Burghardt & Hacker, 2002). The MST movement began to die out when federal dollars ran out, such as Goals 2000 funding, and the MST approach lost significant momentum. Efforts such as the MST standards document for New York state were not implemented as originally designed. High stakes testing also played a role in ending the MST movement in New York. The New York State Education Department website states the following:

> Through the foresight of many, the standard for technology and technology education programs was linked to mathematics and science. Illustrating the interconnectedness of these three subjects the Mathematics, Science, Technology (MST) Learning Standards has created a dynamic force for demonstrating student knowledge. While mathematics and science have had a long history in education, technology education is a relatively new subject with less stature and acceptance. Added to this the testing pressures placed on mathematics and science education, technology education has been overlooked as a tool for improving student achievement. (New York State Education Department, 2006, p. 4)

These examples reiterate the concerns of Gloeckner (1991) and Foster (1994), and others leaders who believe that technology education will never be considered a viable school subject required for study by all students. The greater STEM community must learn from these past events in order to ensure that all STEM stakeholders are well understood. Unfortunately, the leaders from the MST movement failed to fully investigate the complexities of the community of MST teachers; therefore, there was little effort to overcome negative stereotypes or misconceptions of the three subject domains that often stifled building strong teacher partnerships.

Communicating a Clear Mission

Technology education is a very broad term, and that large scope may contribute to its the many misperceptions. Furthermore, there are multiple purposes for teaching technology education in secondary education that have caused great confusion about the purpose of technology education. Although many technology educators today would contend that technology education is important for all students (ITEA, 1996) and that this has been the general mission of technology education since the early 1900s (Foster, 1997); however, there are other educators who focus on technology education as a career pathway. Foster and Wright (1996) document the tension in the 1970s between proponents of industrial arts education for all students versus vocational education. Both purposes of technical education existed and completion for students and funds split resources as well as continued to blur the mission of technology education. Today, divisions still exist in professional teacher education associations with the simultaneous existence of the Technology Education Division (TED) within the Association for Career and Technical Education (ACTE) and International Technology and Engineering Education Association (ITEEA) (Hill, 2006). There are many authors who have written about the lack of uniformity within technology education (Petrina, 1993; Wicklein, 2006; Wright, 1992).

As the engineering education community continues to approach the K-12 arena, it will be critical that engineering educators examine this page from technology education's history. Engineering education must define the main purpose of its role in K-12 education. Is the purpose to improve STEM learning for all children or is the purpose to provide a career pipeline to engineering? Currently, the engineering education literature suggests that both missions for K-12 engineering education exist (Brophy et al., 2009; Douglas et al., 2004; National Academy of Engineering, 2004; Committee on Prospering in the Global Economy of the 21st Century, 2007). Moreover, the funding opportunities that exist in STEM education can cloud the mission of any educational venture. Currently there are over 45 NSF programs that include STEM somewhere in the RFP solicitation (www.nsf.gov, date accessed 5/30/12). Back in 2009, a $100 million of the $787 billion stimulus package was designated for the National Science Foundation (Riley, 2009). In technology education, this "clouding the mission" occurred as early as the late 1800s. Lewis (1996) cited Woodward (1894) as a proponent of manual arts for all children's general education who compromised his ideals of a liberal education of manual arts to an approach to manual training as trade training to acquire needed funds from the Smith-Hughes Act of 1917. Current concerns within the technology education community exist about aligning with engineering education and the greater STEM movement—this could cloud the mission of technology education. "If engineering groups start exercising too much influence on technology education, our field risks a greater association with engineering's vocational or professional orientation, its perceived loyalty to business, and its traditional political alliances" (Pannabecker, 2004, pp. 79-80). Another concern for technology educators is t hat "by focusing heavily on pre-engineering, technology education also is 'vocationalized' to the extent that it is limited primarily to prepare youth to enter into a specific occupational field" (Herschbach, 2009, p. 240). It is quite possible that members of technology education express these concerns because engineering education has not communicated its intentions or purpose for K-12 engineering education.

Salinger (2005) has suggested that the study of K-12 engineering should not be vocational but it should be taught as a way of thinking. In his paper *The Engineering of Technology Education*, he challenges technology educators to use the process outlined in *Understanding by Design* (Wiggins & McTighe, 2005) to help the field of technology education establish its mission regarding teaching engineering within technology education. Salinger (2005) suggested technology educators ask themselves the question, "What is the goal?" In other words, they should identify what the purpose is to infuse engineering concept into technology education. The author of this article believes the same question can be applied to engineering education regarding its role in K-12 education: What is the goal?

Conclusion

The overarching purpose of this article was to share some commonalities between technology education and engineering education and strong, almost eerie parallels of technology education history with engineering education and the current STEM education movement. Salinger (2005) provided this challenge to the field of technology education:

> The technology education profession has worked hard on the issue of the content of its discipline and on how to be educated to teach it (ITEA, 2000/2002); but perhaps needs to think more strategically about other dimensions like where can it get support? (p. 3)

The author of this article would like to suggest that T and the E should work harder to provide support for one another. Of all the STEM stakeholders who sit at the "STEM table," members of the technology and engineering fields are best positioned to sit the closest; as a result their contribution to K-12 STEM education will be strengthened. Consider the words of engineering educators Haghighi, Smith, Olds, Fortenberry, and Bond (2008) as they spoke regarding engineering education's future: "We must form win-win partnerships not only in areas such as cognitive science but also in the interdisciplinary context of the larger engineering college as well as the K-12 community and community colleges" (p. 120).

Taking a page from Frans Johansson's (2004) best-selling book: *Medici Effect: Groundbreaking Innovation at the Intersection of Ideas, Concepts, & Cultures*, the author of this article suggests that technology education and engineering education strengthen their positions within STEM by locating the key intersections within these fields of study. If fields suffer from a lack of a clear mission, partnering to explore common intersections would be prudent. Possibly one of the greatest opportunities to begin to define a clear mission is to simultaneously establish a clear research agenda. What are the intersections between a technology education research agenda and an engineering education research agenda? This author believes that both fields must discover through research the benefits that exist in teaching engineering in K-12 classrooms. Does teaching in the context of engineering design improve students' STEM learning? These are just a few questions that should be asked by researchers within technology education and engineering education. Unfortunately with current state's budget constraints in K-12 education, the T and the E are in possible jeopardy of funding cuts; some cuts have already occurred. It is now time to conduct rigorous research that speaks loudly to policy makers—a strong partnership between the T and the E can begin to build a clear research agenda.

Dr. Todd R. Kelley is an assistant professor in the College of Technology (and P-12 STEM Researcher) at Purdue University, West Lafayette, Indiana. He is a member of Phi Chapter of Epsilon Pi Tau.

References

American Association for Advancement of Science. (1989). *Project 2061: Science for all Americans.* Washington, DC: Author.

Bennett, C. A. (1926). *History of manual and industrial education up to 1870.* Peoria: Bennett.

Bonser, F. G. (1911). Fundamental values in industrial education. *Teachers College Bulletin III* (November 18). New York: Teacher's College, Columbia University.

Bonser, F. G. (1926). *A history of industrial arts in Teachers College, to May, 1926.* [Unpublished manuscript, Milbank Memorial Library, Teachers, College, Columbia University, New York.]

Bonser, F. G. (1932). Bibliography. In *life needs and education* (pp. 271-288). New York: Teachers College, Columbia University.

Bonser, F. G., & Mossman, L. C. (1923). *Industrial arts for elementary schools*. New York: Macmillan.

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

Brophy, S., Kelin, S., Portsmore, M., & Rogers, C. (2008). Advancing engineering education in P-12 classrooms. *Journal of Engineering Education.* 369-382.

Brosterman, N. (1997). Child's play. *Art in America, 85*(4), 108-111, 130.

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

Capozzoli, P., & C. Rogers. 1996. LEGOs and aeronautics in kindergarten through college In *Proceedings of the Advanced Measurement and Ground Testing Technology Conference*. New Orleans, LA.

Coleman, D. (2008). Long before Legos, wood was nice and did suffice. The New York Times, 11.

Connolly, K. G., Wendell, K. B., Wright, C. G., Jarvin, L., & Rogers, C. (2010). Comparing children's simple machines learning in LEGO(TM) engineering-design-based and non-LEGO engineering-design-based science environments. Paper presented at the Annual International Conference of the National Association for Research in Science Teaching (NARST), Philadelphia, PA.

Committee on Prospering in the Global Economy of the 21st Century (2007). Rising above the gathering storm: Energizing and employing America for a brighter economic future. National Academy of Science. Washington, DC: National Academies Press.

Daugherty, M.K., & Wicklein, R.C. (1993). Mathematics, science, and technology teachers' perceptions of technology education. *Journal of Technology Education, 4* (2), 28-43.

Dewey, J. (1915, May 15). Education vs. trade-training. *New Republic*, pp. 40-43.

Douglas, J., Iversen, E., & Kalyandurg, C. (2004). Engineering in the K-12 classroom: An analysis of current practices and guidelines for the future. A production of the ASEE Engineering K12 Center.

Dym, C., Agogino, A., Eris,O., Frey, D., & Leifer, L (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 95*(1), 103-120.

Erwin, B., Cyr, M., & Rogers, C. 2000. LEGO engineer and ROBOLAB: Teaching engineering with LabVIEW from kindergarten to graduate school. I*nternational Journal of Engineering Education* 16(3), 181–92.

Foster, P. (1994). Must we MST? *Journal of Technology Education, 6*(1), 76-84.

Foster, P. N. (1995). The founders of Industrial Arts in the U.S. *Journal of Technology Education. 7*(5), 6-21.

Foster, P. N. (1997). Lessons from history: industrial arts/ technology education as a case. *Journal of Vocational and Technical Education*, 13(2), 5-15.

Foster, P. N., & Wright, M. D. (1996). Selected leaders' perceptions of approaches to technology education. *Journal of Technology Education, 7*(2), 13-27.

Gloeckner, G. (1991). The integration of science, technology, and mathematics myth or dream? *Journal of Technology Education, 2*(2) 1-7.

Haghighi, K., Smith, K.A., Olds, B. M., Fortenberry, N., & Bond, S. (2008). The time is now: Are we ready for our role? *Journal of Engineering Education, 97*(2), 119-121.

Hansen, R. E. (1995). Teacher socialization in technological education. *Journal of Technology Education, 6*(2), 34-45.

Herschbach, D. (2009). *Technology education: Foundations and perspectives.* Homewood, IL: American Technical Publishers, Inc.

Hill, R. B. (2006). New perspectives: Technology teacher education and engineering design. *Journal of Industrial Teacher Education, 43*(3), 45-63.

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

International Technology Education Association. [ITEA]. (2000/2002) *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

Katehi, L., Pearson, G., & Feder, M. (Eds.). (2009). *Engineering in K-12 education: Understanding the status and improving the prospectus.* Washington, DC: National Academies Press.

Johansson, F. (2004). *The Medici effect: Breakthrough insights at the intersection of ideas, concepts, & cultures.* Cambridge, MA: Harvard Business School Press.

Kirkwood, J. J. (1994). Construction in elementary school technology education. In J. W. Wescott & R. H. Henak (Eds.). *Construction in technology education* (pp. 75-101). Peoria, IL: Glencoe.

Kilpatrick, W. H. (1918, September). The project method. *Teachers College Record, 19*(4), p. 319–35.

Kilpatrick, W. H. (1925). *Foundations of method*. New York: Macmillan.

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

Lewis, T. (1996). Accommodating border crossings. *Journal of Industrial Teacher Education, 33*(2), 7-28.

Mossman, L. C. (1924). *Changing conceptions relative to the planning of lessons.* New York: Teachers College, Columbia University.

Mossman, L. C. (1929). The content of the social studies in the elementary school. *Teachers College Record, 30*(4), 322-333.

Mossman, L. C. (1938). *The activity concept: An interpretation.* New York: Macmillan.

National Academy of Engineering. (2004). *The Engineer of 2020*. Washington, DC: The National Academy Press.

National Research Council (1989). *Everybody counts: A report to the nation on the future of mathematics education.* Washington, DC: National Academy Press.

New York State Education Department. (2006). NYS Technology Education Framework Initiative, p. 4. Retrieved September, 15, 2009. http://www.emsc.nysed.gov/cte/technology/initiative /home.html

Pannabecker, J. (2004). Technology education and history: Who's driving? *Journal of Technology Education, 16*(1), 72-83.

Petrina, S. (1993). Diversity, not uniformity united, not standardized: A reaction to Wright's "challenge to all technology educators." *Journal of Technology Education, 4*(2), 69-76.

Riley, S. (2009, March, 10). Tech education will get some funding from stimulus effort. *Investor's Business Daily Inc.*

Salinger, G. (2005). The engineering of technology education. *Journal of Technology Studies, 31*(1), 2-6.

Sanders, M. (2009) STEM, STEM education, STEMmania. *The Technology Teacher, 68*(4). 20-26.

Scott, J. L., & Sarkees-Wircenski, M. (2004). *Overview of career and technical education.* Homewood, IL: American Technical.

Wicklein, R. C. (2006). Five good reason for engineering design as the focus for technology education. *The Technology Teacher, 65*(7), 25-29.

Wiggins, G. P., & McTighe, J. (2005). *Understanding by design.* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Woodward, C. (1894). *New demands upon schools by the world's industries.* Proceedings of the International Congress of Education of the World's Columbian Exposition, New York: National Education Association.

Wright, T. (1992). Building a defensible curriculum base. *Journal of Technology Education, 3*(2), 62-66.

Nanotechnology Safety Training: Addressing the Missing Piece

Dominick E. Fazarro and Walt Trybula

Abstract

This OSHA Susan Harwood Grant addressed nanotechnology safety training for workers and was critical for building a path for future training/education courses. The purposes of the grant were to facilitate training and to assess the outcomes of the participants' knowledge. Two trainers went to four sites in the United States, including one in Puerto Rico, to conduct eight-hour courses in the Environmental, Health, and Safety (EHS) implications of nanomaterials

A survey was distributed to participants at the end of the course to assess the quality of the course and the instructors. Overwhelmingly, approximately 95% of the participants were satisfied with the quality of the course and instruction.

A pretest was given to the participants to assess if they knew anything about EHS, and a posttest was administered after the training course. A hypothesis test was used to determine the effectiveness of the content of the course. A paired samples t-test was used to ascertain whether there was an improvement in scores from the pretest to the posttest. The findings indicated a statistically significant difference between the group mean scores from the pretest to the posttest. In essence, the participants improved from the pretest to the posttest scores as a result of the training. However, there are caution should be taken when addressing the results as the sole indicator of the participants' success.

Introduction

The purpose of this article is to illustrate the findings/assessment of the program funded by an OSHA Susan Harwood Grant. Although huge amounts of data were collected for this article, the authors displayed only data that directly addressed the research questions.

Nanotechnology is emerging as the next frontier of cutting-edge science and engineering. Nanotechnology has provided researchers and industry with a new avenue to develop products that may revolutionize the world as we view it. The National Nanotechnology Initiative has estimated that by 2015, the economic global impact of nanotechnology could reach around $1 trillion (Wedin, 2006). Industry has the monumental challenge of preparing a workforce to think and develop below the 100-nanometer (nm) level. Working with materials on the nanoscale requires specialized training and a technical background that is needed to manufacture engineered nanomaterials (ENMs) (Trybula, Fazarro, & Kornegay, 2009). Researchers, technicians, manufacturing engineers, and production workers will be needed for a nanotechnology workforce (NNI, 2009). Dr. Mihail Roco, NSF Senior Advisor on Nanotechnology, is one of the leaders promoting nanotechnology workforce education/training. By 2015, there will be approximately two million workers globally in nanotechnology (Roco, 2003). Roco stressed the training of people is vital for long-term success in the field of nanotechnology (Roco, 2001).

Workers are producing carbon nanotubes in various applications (e.g., conductive plastics and aeronautical uses) (Nanocyl, 2009). The workforce in these types of companies, such as SouthWest NanoTechnologies, Bayer, and Nanocomp Technologies, which produce ENMs is estimated to contain at least 620 workers. The estimated growth for this product is at an annual pace of 15-17%, and this represents only one of many different classes of nanomaterials (Nanoparticle Task Force ACOEM, 2011). A report identified 61 U.S.-based companies that manufacture or handle carbon-based nanomaterials, in particular carbon nanotubes (Nanoparticle Task Force ACOEM, 2011). This report is disturbing because 61 companies may have inadequate safety procedures for workers who handle EMNs, and most important, workers may not have the proper training to identify potential hazards, which may be very dangerous to welfare of workers and others outside the confines of the workplace. According to studies, some carbon nanotubes—the most researched and produced in the industry, from a technological and toxicological viewpoint—have produced asbestos-like symptoms in rodents (Takagi, Hirose, & Nishimura, 2008). Moreover, work is needed to research both the physical and chemical properties of nanomaterials and how these properties relate to unwanted health effects. The properties of nanomaterials cannot be generalized to determine health and safety effects (Fazarro & Trybula, 2011). As new EMNs emerge, there is an increase in the uncertainty of how they will behave (Shatkin et al., 2010). Research about the properties of EMNs will be ongoing; however, there is a need to properly train U.S. nanoworkers in safety.

National and Global Perspective on Nanotechnology Safety

A number of government organizations, such as CDC, NIOSH, NIST, FDA, and ICON, are aggressively establishing a foundation to define fundamentals of nanotechnology safety content. In 2011, the following government organizations were funded to address the research needs to maintain a safe workplace: The U.S. Food and Drug Administration (FDA) requested $15 million; The National Institute for Occupational Safety and Health (NIOSH) requested $16.5 million; and the National Institute for Standards and Technology (NIST) doubled its nanotechnology safety research from $3.6 to $7.3 million (Maynard, 2010). According to Fazarro & Trybula (2011), “This effort to push nanotechnology safety research is novel; however, there is a need for a parallel effort to implement education and training” (para 4). Maintaining workers’ health and avoiding litigation would be a beneficial by-product of avoiding accidents that can result to public mistrust. So, what should be done to prepare this growing workforce to meet the needs of the industry?

U.S. Senators Mark Pryor and Benjamin L. Cardin have introduced the Nanotechnology Safety Act of 2010 (Pryor, 2010) to address future health and safety concerns. According to Mark Pryor:

> Nanotechnology is one of the most important and enabling technologies being developed right now, and it has hundreds of promising applications – from new cancer treatments to improved military machinery to stain-resistant pants," . . . "As these products are developed and used, we must understand any potential risks to human health, safety or the environment. My legislation will help ensure public safety and confidence in the marketplace, and it will support companies that employ nanotechnology materials. (para. 1)

Benjamin Cardin added, "Nanotechnology touches so many facets of our lives today and will play a greater role in the future, but the benefits to industry and consumers come with unknown risks that must be identified and managed appropriately" (Pryor, 2010, para. 3).

A 2011 report entitled *EPA Needs to Manage Nanomaterial Risks More Effectively* provided concerns of industries that produce nanomaterials. The EPA concluded:

> EPA does not currently have sufficient information or processes to effectively manage the human health and environmental risks of nanomaterials. EPA has the statutory authority to regulate nanomaterials, but currently lacks the environmental and human health exposure and toxicological data to do so effectively (U.S. Environmental Protection Agency, 2011, p. 3).

According to this EPA report, there is evidence that agencies that are involved in nanotechnology in the United States are still behind in establishing Environmental, Health, and Safety (EHS) standards.

Regarding the global perspective, the European Commission (2012) is well ahead of the United States in addressing EHS issues of nanotechnology to devise an integrated approach to be safe and responsive toward EMNs. The European Parliament demanded a framework to establish regulations for (1) reviewing and adapting EU laws, (2) monitoring safety issues, and (3) engaging in dialogue with national authorities, stakeholders, and citizens. The European Commission favors the development of nanotechnology; however, safety behavioral, and ethical responsibility should be paramount.

China is behind Europe and the United States on safely handling nanomaterials. China has been focused on the biological and environmental effects of manufactured EMNs (Zhao, Zhao, & Wang, 2008). According to Jarvis and Richmond (2010), some generational gaps (e.g., Baby Boomer, Generation X, & Generation Y) exist among researchers on how to approach EHS difficulties of nanomaterials. This can be a serious problem in the future in terms of worker safety and perhaps increased illnesses and deaths in the workplace.

The National Nanotechnology Initiative (NNI) (2010) conducted a study on Chinese nanotechnology. The NNI concluded that scientific gaps are evident, which include little data to support workers' exposure to nanoparticles/nanomaterials at the worksite. Also, workers who have been examined had been exposed for long as 13 months. China has not created sufficient and suitable industrial hygiene practices to protect workers; to exacerbate the problem peasants were employed at the worksite that did not have any formal training in industrial hygiene or knowledge of the toxicity effects of the nanoparticles/nanomaterials at the worksite.

The Next Step

Unlike general safety training programs, such as HAZWOPER (safety training for the micron world), the nano world is very different, and content must be designed so that workers can understand the environmental, health, and safety hazards of manufactured materials below the 100nm realm. In the semiconductor industry, workers design products in the micro realm. In this area, safety practices have been established for over 30 years. Safety awareness at the nanolevel is mind-boggling, and it is complicated to imagine workers developing materials that are far beyond the naked eye. Opening up a new arena in which industry, researchers, and government agencies have barely scratched the surface dealing with the EHS issues, will be a monumental challenge.

The lead university (Rice University), Texas State University, and the University of Texas at Tyler collaborated to receive funding for the country's first OSHA grant addressing the training needs of safely handling nanomaterials in the workplace. The grant addressed the critical and urgent need for rigorous, science-based, and comprehensive training materials to directly address the safe handling of nanomaterials. There are best practices (CDC, 2012; OSHA, 2012; Good Nano Guide, 2011) for safely handling nanomaterials published on websites. However, no empirical studies have addressed perceptions and effectiveness of training workers on nanotechnology safety.

Training Content Development

The development of the training package is derived from the brightest minds in nanotechnology safety as represented by organizations such as the Center for Biological and Environmental Nanotechnology (CBEN)—Rice University, The Lippy Group, Texas State University, The University of Texas—Health and Science Center at Houston, and the International Chemical Workers Union. Internal and external advisory boards were formed to ensure the topics were taught and input was provided for program improvement.

The training program consisted of establishing an eight-hour course to cover ENM occupational health and safety issues to emphasize human exposure. Seven topics were used to develop the modules. See Figure 1 for illustration. Two trainers went to four locations, including Puerto Rico, to conduct the training. A research study was conducted to ascertain both if learning outcomes were achieved and participants' perspectives on the program.

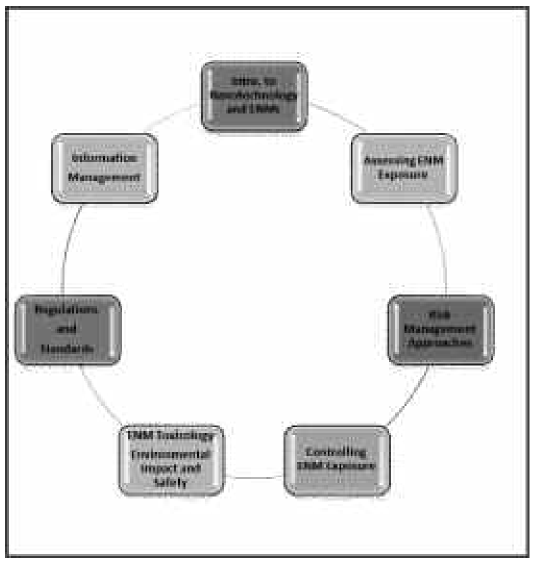

Figure 1. Seven modules used for training program funded by OSHA-Susan Harwood

Purpose of Study

The purpose of this study was twofold: (1) determine if the participants successfully completed the seven topics and (2) determine the participants' perspectives of the program. To ascertain the success of the program, research questions and hypothesis statements were developed.

Research Questions

1. What were the participants' *Cohort 2011* perceptions on the Nanotechnology Safety Training?

2. Was there a difference between the participants' *Cohort 2011* mean scores on the pretest and posttest?

The hypotheses statements that follow are at a .05 alpha level for research question 1. The alpha level of .05 is commonly used in education because of the likelihood of making Type I and Type II errors.

Hypothesis Statement

1. Ho: There is no difference between the participants' mean scores on the pretest and posttest.

   Ha: There is a difference between the participants' mean scores on the pretest and posttest.

Methodology

Research Design

The research design for hypothesis statement 1 employs a minimal control, one-group, pretest-posttest design (Campbell & Stanley, 1966). Even though there can be a significant result from the design, there are disadvantages. For example, there is no assurance that the treatment (training material) will be the only major factor in participants' learning.

Research question two uses a survey research (descriptive) design to obtain the participants' perspectives. According to Isaac and Michael (1997), this research method is used "to describe systematically a situation or area of interest factually and accurately" (p. 46).

Statistical Analyses Used

The study utilized descriptive analysis and a paired samples t-test. The rationale for the descriptive analysis was to collect the frequency of the participants' perception based on the 4-point Likert scale. The paired samples t-test was used to determine if there was an increase in the group-mean scores from the pretest to posttest.

Population of Participants

The nanotechnology safety training targeted small- to medium-sized ENM fabrication plants, processing companies, and research facilities. There are many small- to medium-sized companies that have no (or few) dedicated safety professionals on staff; instead, in such companies an engineer or a scientist (if anyone at all) may be tasked with health and safety duties as an adjunct to that staff member's primary responsibilities. A worker who fulfills such a dual role must find and apply reliable information about the safe handling of ENMs so that he or can disseminate critical information within a facility. Even when a trained safety professional is on staff, the worker will likely have had little prior experience specifically with ENMs and would benefit from learning how to apply his or her existing professional knowledge to this new class of materials.

Flyers were used for each site to invite workers to receive training. Tables 1a and 1b illustrate the training sites and number of attendees for 2011.

Table 1a: Training Locations

Training Location	City-State/Territory
Mission College	Santa Clara, CA
Univ. of Cincinnati	Cincinnati, OH
Labor College	Silver Spring, MD
University of Puerto Rico	Puerto Rico

Table 1b: Number of Participants by Training Location

Training Location	No. of Attendees #
Mission College	11
Univ. of Cincinnati	37
Labor College	25
University of Puerto Rico	30

n = 103

There was a wide range of participants, differentiated by job title and level of education, who attended the training sessions for 2011. See Tables 2a and 2b.

Table 2a: Number of Participants by Job Title

Job Title	No. of Attendees*
Environmental Health	3
Injury and Prevention Control	1
Occupational Safety	25
Occupational Health Nursing	1
Occupational Medicine	4
Industrial Hygiene	23
Other	

* Note: The number of attendees from the Table 2a does not reflect the number of attendees in Table 1b. There were some people who dropped out or left early.

Instruments for Study

The instruments for the study were a pretest, posttest, and end-of-the-course survey. The pretest consisted of 14 questions (5 true/false), and 9 short-answer questions). The

Table 2b: Number of Participants by Level of Education

Education Level	No. of Attendees*
High School	5
Some College	13
Associate Degree	2
Bachelor of Arts or Science	30
MS/MA/MPH	7
Doctorate	44

* Note: The number of attendees from the Table 2a does not reflect the number of attendees in Table 1b. There were some people who dropped out or left early.

posttest contained the same number of questions; however, the questions were reworded and ordered differently. The end-of-the-course survey contained three sections (demographic, rate the instructors, and course experience), for a total of 15 questions. There were14 statements with a 4-point Likert-type scale (Excellent, Good, Fair, and Poor). Cronbach's alpha was performed by Statistical Package for the Social Sciences (SPSS) to test for reliability of the survey instrument. There was a reliability of .721, which is considered acceptable. Face validity was conducted by the internal and external advisory panel to assess whether or not the questions were appropriate to evaluate the participants in the training program.

To prevent internal threat to validity, the posttest questions were rearranged and reworded slightly from the pretest. The instruments were developed to address assessment needs for reporting to OSHA.

Data Collection Procedures

The data from the pretests, posttests, and end-of-the-course evaluations were collected at the end of the training sessions for each site. Data were collected and stored on Excel spreadsheets. Steps were taken to ensure the pretests and posttests score were matched by participant. The data were imported to SPSS to generate results.

Results

Survey Results

The results are displayed in this section for the research questions. The SPSS-Crosstab function was used to generate frequencies by the 4-point Likert-type scale for each statement that was answered by the participants. The research question stated, *What were the participants' (Cohort 2011) perceptions of the Nanotechnology Safety Training?* Tables 3-5 addressed the quality of the course by each training site. Participants at the training sites—Santa Clara, University of Cincinnati, Labor College, and University of Puerto Rico believed that the content suited their requirements. See Table 3.

Participants at the training sites (Santa Clara, Univ. of Cincinnati, Labor College, and Univ. of Puerto Rico) responded good to excellent that the topics were covered in detail. See table 4.

Table 5 illustrates the majority of the participants at each training site rated the nanotechnology safety course was good to excellent.

Table 3. Was the content suited to your requirements?

n = 103

	Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Not Answered**	**Total**
Santa Clara	1	5	4	1	11
University of Cincinnati	3	18	16	0	37
Labor College	4	17	4	0	25
Univ. of Puerto Rico	4	12	14	0	30

Table 4. Were the topics covered in sufficient detail?

n = 103

	Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Not Answered**	**Total**
Santa Clara	0	8	3	0	11
University of Cincinnati	5	16	15	1	37
Labor College	0	13	12	0	25
Univ. of Puerto Rico	3	14	13	0	30

Table 5. Overall rating of the course follows:

$n = 103$

Likert-Type Scale					
Training Site	**Fair**	**Good**	**Excellent**	**Not Answered**	**Total**
Santa Clara	0	6	5	0	11
University of Cincinnati	1	16	20	0	37
Labor College	1	10	12	2	25
Univ. of Puerto Rico	1	13	16	0	30

Table 6. Instructors have the ability to provide real world experience.

$n = 103$

Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Total**
Santa Clara	0	5	6	11
University of Cincinnati	5	15	17	37
Labor College	2	3	20	25
Univ. of Puerto Rico	1	10	19	30

Table 7. Instructors have knowledge of the subject matter.

$n = 103$

Likert-Type Scale			
Training Site	**Good**	**Excellent**	**Total**
Santa Clara	2	9	11
University of Cincinnati	7	30	37
Labor College	2	23	25
Univ. of Puerto Rico	7	23	30

Table 8. Instructors' presentation abilities were . . .

$n = 103$

Likert-Type Scale					
Training Site	**Fair**	**Good**	**Excellent**	**Not Answered**	**Total**
Santa Clara	0	1	9	1	11
University of Cincinnati	1	14	22	0	37
Labor College	0	8	17	0	25
Univ. of Puerto Rico	1	4	25	0	30

Table 9. Overall rating of the instructors . . .

$n = 103$

Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Total**
Santa Clara	0	1	10	11
University of Cincinnati	1	7	29	37
Labor College	2	4	21	25
Univ. of Puerto Rico	1	5	25	30

Table 10. Materials, handouts, and activities useful . . .

$n = 103$

Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Total**
Santa Clara	0	7	4	11
University of Cincinnati	4	13	20	37
Labor College	1	12	12	25
Univ. of Puerto Rico	1	13	16	30

The next tables address the quality of the instructors and materials by each training site. See Tables 6 through 11. In all training sites for Table 6, participants believed the instructors did a good to excellent job providing real-world experience for safely handling nanoscaled materials. The majority participants in the training program indicated the instructors provided real-world experience to the course. See table 6.

The participants at the training sites rated the instructors' knowledge of nanotechnology safety from good to excellent. See table 7.

In Table 8, participants who completed the survey rated the instructors' abilities to present the material as good to excellent. See Table 8.

The majority of participants at the training sites rated the instructors as excellent for delivering the training materials. See Table 9.

The participants perceived the materials, handouts, and activities were useful for the training course. See Table 10.

In Table 11, all participants from the training sites rated the quality of the overall materials from good to excellent.

Tables 12-14 illustrate the importance of having nanosafety certification at the worksite.

All participants who answered the survey question agreed that they would consider being certified.

About 50% of the participants at the training sites would consider being certified in nanotechnology safety. See Table 12.

Three out of four training sites agreed that certification would be valuable to the participant and to the employer. University of Cincinnati was split on whether nanotechnology safety certification would be valuable to the company as well as for the individual. See Table 13.

All four of the training sites agreed or strongly agreed that certification in nanosafety is important to the field. Ten participants from

Table 11. Overall quality of the training materials

n = 103

	Likert-Type Scale				
Training Site	**Fair**	**Good**	**Excellent**	**Not Answered**	**Total**
Santa Clara	0	6	5	0	11
University of Cincinnati	0	16	19	2	37
Labor College	0	13	12	0	25
Univ. of Puerto Rico	1	8	20	1	30

Table 12. After this training, would you consider becoming certified in nanosafety?

n = 97*

	Decision Type			
Training Site	**Yes**	**No**	**Do not know**	**Total**
Santa Clara	9	0	1	10
University of Cincinnati	20	15	1	36
Labor College	10	11	0	21
Univ. of Puerto Rico	26	4	0	30

*Note: Six participants did not answer.

Table 13. Would certification in nanotechnology safety be valuable to you and your employer?

n = 96*

	Decision Type			
Training Site	**Yes**	**No**	**Do not know**	**Total**
Santa Clara	10	0	0	10
University of Cincinnati	18	15	3	36
Labor College	17	8	0	25
Univ. of Puerto Rico	25	0	0	25

*Note: Seven participants did not answer.

Table 14. Certification in nanotechnology safety is important to the field.
n = 96*

	Likert-Type Scale					
Training Site	**strongly disagree**	**disagree**	**neutral**	**agree**	**strongly agree**	**Total**
Santa Clara	0	0	1	7	2	10
University of Cincinnati	1	2	8	16	8	35
Labor College	0	0	0	11	10	21
Univ. of Puerto Rico	0	0	0	30	0	30

*Note: Seven participants did not answer.

Labor College agreed strongly that to obtain certification is important. See Table 14.

To determine effectiveness of the course training, a paired-samples t-test was used. The paired-samples t-test requires a sample size of 30+ (Pallant, 2005), which was adequate for answering the hypothesis statement. The material taught at each training site was identical and grouped as Cohort 2011 to achieve the necessary sample size. Ninety-eight participants completed the pretest and posttest. Determining significance for each training site was not possible because of the unequal sizes of the enrollment. To verify the SPSS output was valid, assumptions were checked to determine if there were any violations. There were no violations in the assumptions.

The paired-samples t-test was conducted to determine the course effectiveness—if there was an increase of the mean group score of the participants from the pretest to posttest based on the training material taught. There was a statistically significant increase in the posttest scores from the pretest ($M = 7.939$, $SD = 5.9327$) to the posttest [$M = 15.571$, $SD = 4.7883$, $t(98) = -13.482$, $p < .0005$]. Therefore, the null hypothesis was rejected and the alternative accepted.

Conclusion and Discussion

The study concluded with positive results for the training program. According to the posttest scores, there was a significant improvement in the participants' knowledge of nanosafety. Even though the participants started at different levels from the pretest, the variation of improvement on the posttest was about even across the training sites. Testing the hypotheses to determine whether there was a significant change in the pretest and posttest group mean score was based on the effectiveness of the training. The study also revealed a statistically significant difference in the pretest and posttest group mean score, which meant that the training material was effective and contributed to the improvement in the posttest scores. The authors suggest that readers approach the findings with caution. The significance of the study is only generalized to the four training sites. One must conclude that there were uncontrollable external variables (i.e., monetary incentives, self-motivation), which may have contributed to the increase of the mean group score of the posttest.

In Tables 13 and 14, the participants believed that nanotechnology safety training is important for the viability of companies who manufacture nanomaterials. Thus, in Table 12, participants agreed that certification would be important to the participants. Agencies like NIOSH, OSHA, and professional organizations—ATMAE, IEEE, ASSE, and others—could pave the way to developing certification. ATMAE has a certification division with four certification exams already developed and in use. As ATMAE expands the organization for new skill sets to continue to meet industries' demands, the organization can be a support mechanism to assist in implementing nanotechnology safety courses. To make this certification a reality, more collaboration is needed among government agencies, industries, and other professional organizations to create a valid and comprehensive nanotechnology safety certification.

The funded grant on training workers in nanotechnology safety is groundbreaking and a catalyst to make educators and government agencies aware of the importance of nanotechnology safety training. As more ENMs are created, industry must become more cognizant of the training needs of the workers. Constant improvement of training materials from research and industry practice will be vital to the field of nanotechnology. A workforce that is well trained in safely handling nanoscale materials will lessen the likelihood of catastrophes and decrease public skepticism. Training materials on nanosafety will become available to the public soon on the OSHA website; however, The Good Nano Guide has similar materials, which are available to the public.

Dr. Dominick E. Fazarro is an Associate Professor in the Department of Human Resource Development and Technology at The University of Texas at Tyler. He is a Member-At-Large of Epsilon Pi Tau.

Dr. Walt Trybula is a Senior Researcher at Ingram School of Engineering at Texas State University, San Marcos.

References

Campbell, D. T., & Stanley, J. C. (1966). *Experimental and quasi-experimental designs for research.* Chicago, IL: Rand McNally & Co.

Center for Disease Control and Prevention (CDC) (2012). *Worker safety & health topics-nanotechnology*. Retrieved from http://www.cdc.gov/niosh/topics/nanotech/

European Commission (2012). *Public Health.* Retrieved from http://ec.europa.eu/health/nanotechnology/policy/index_en.htm

Fazarro, D., & Trybula, W. (2011, August). *Empowering academia to look into the future: Nanotechnology safety education-creating the workforce that you will need.* Paper session presented at the meeting of IEEE NANO 2011 Conference, Portland, Oregon.

Good Nano Guide (2011). Retrieved from http://www.goodnanoguide.org/tiki-index.php?page=HomePage

Isaac, S., & Michael, W. (1997). *Handbook in research and evaluation: For education and the behavioral sciences* (3rd ed.). San Diego, CA: EdITS/Educational and Industrial Testing Services.

Jarvis, D., & Richmond, N. (April, 2010). *Mapping emerging nanotechnology policies and regulations: The case of the People's Republic of China.* Paper presented at the Lee Kuan Yew School of Public Policy-Working Paper Series, Singapore.

Maynard, A. (2010, February 18). *US government kicks nanotechnology safety research up a gear. 2020 Science: A clear perspective on emerging science and technology.* Retrieved from http://2020science.org/2010/02/18/us-government-kicks-nanotechnology-safety-research-up-a-gear/

Nanocyl (2009). *What is a nanocarbon tube?* Retrieved from http://www.nanocyl.com/CNT-Expertise-Centre/Carbon-Nanotubes

Nanoparticle Task Force ACOEM (2011). Nanotechnology and health. *Journal of Occupational & Environmental Medicine, 53*(6), 687-689.

National Nanotechnology Initiative (NNI) (2009). *Nanotechnology: Big things from a tiny world* Retrieved from http://www.nano.gov/html/society/ Educations.html

National Nanotechnology Initiative (NNI) (2010). *Chinese nanotechnology study: Fact sheet.* Retrieve from http://www.nano.gov/node/162

Occupational Safety & Health Administration (OSHA) (2012). *Nanotechnology safety standards.* Retrieve from http://www.osha.gov/dsg/nanotechnology /nanotech_standards.html

Pallant, J. (2005). *SPSS survival manual* (2nd ed.). Chicago: SPSS, Inc.

Pryor, M. (2010, January 21). Pryor, Cardin call for increased research to ensure product *safety* cite Arkansas facility and Maryland HQ as ideal locations for nanotechnology studies [Press Release]. Retrieve from http://www.pryor.senate.gov/public/v index.cfm?p=PressReleases&ContentRecord_id=92f252e2-7d7c-453d-8be8-f80c3f764ec8

Roco, M. (2001). International strategy for nanotechnology research and development. *Journal of Nanoparticle Research, 3* (5-6), 353-360.

Roco , M. C. (2003). Converging science and technology at the nanoscale: Opportunities for education and training. *Nature Biotechnology, 21*(10), 1247-28. doi:1016/S0958-1669 (03)00068-5

Shatkin, J., Abbott, L. C., Bradley, A. E., Canady, R. A., Guidotti, T., Kulinowski, K. M., Williams, M. (2010). Nano risk analysis: Advancing the science for nanomaterials risk management. *Risk Analysis, 11* (30), 1680-1687.

Takagi, A., Hirose, A., Nishimura, T. (2008). Induction of mesothelioma in p53+/- mouse by intraperitoneal application of multi-wall carbon nanotube. *Journal of Toxicological Sciences 33*(1), 105-116.

Trybula, W., Fazarro, D., & Kornegay, A. (2009). The emergence of nanotechnology: Establishing the new 21st century workforce. *The Online Journal for Workforce Education and Development, 4* (3), 1-10. Retrieved from http://wed.siu.edu/Journal/ VolIIInum4/Article_6.pdf

U.S. Environmental Protection Agency-Office of Inspector General. (2011). *Needs to manage EPA nanomaterial risks more effectively* (EPA Publication No. 12-P-0162). Retrieved from http://www.nanolawreport.com/uploads/file/EPA%20Needs%20to%20 Manage%20Nanomaterial%20Risks%20More%20Effectively.pdf

Wedin, R. (2006). Is nanotechnology safe? Retrieved from http://www.wedincommunications.com/Chemistry%20Nanotech%20Spring06.pdf

Zhao, F., Zhao, Yuliang, & Wang, C. (2008). Activities related to health, environmental and societal aspects of nanotechnology in China. *Journal of Cleaner Production, 16*, 1001-1002.

Developing Occupational Programs: A Case Study of Community Colleges

Duane E. Doyle

Abstract

A progressively more technological and competitive employment environment in today's world economy requires employees to have a firm understanding of critical technical skills to build on when they arrive at the workplace. This study examines how differences in the environmental conditions and organizational factors facing four community colleges contributed to the development of occupational and technical education programs.

This study was driven by one primary research question: What environmental conditions and organizational factors influence the nature of the strategic response in the form of technical education program development within community colleges? To answer this question, a qualitative study of both stakeholders in higher education (which included individuals at four community colleges in the state of Arkansas) and individuals at the Arkansas Department of Higher Education was conducted. The institutions selected represented the widest possible range of organizations.

A conceptual framework was developed that included previous research on normative, regulative, and cultural-cognitive environments and organizational response processes. The framework served as a guide to identify how external conditions in these processes influence the nature of the development of occupational and technical education programs at community colleges in Arkansas.

Key Words: Program Development, Occupational Education, Technical Education, Case Study, Environmental Response, Organizational Theory

Introduction

Recent decades have witnessed a growing discrepancy in the income of workers with different levels of education. Individuals with high school diplomas or less education saw their earning potential fall throughout much of the 1980s and 1990s compared with those who had more education. Between the years 1979 and 2005, real hourly wages rose for college graduates by 22%; for high school graduates they remained stagnant, and for high school dropouts, wages fell by 16% (Mishel, Bernstein, & Allegretto, 2005). Fewer than 50% of low-income workers, had more than a high school degree in 2003, and about 20% percent of these were high school dropouts (Acs & Nichols, 2007).

Even before the recent recession people who had minimal skills landed few jobs offering any noteworthy or lasting wage increases over time, fundamentally because they lacked the basic skills and education needed to advance. In a 2005 study, Anderson, Holzer, and Lane found that although low-wage earners experienced some gains in earnings over time, no more than one quarter of them permanently escaped their low-wage status. Several low-skill workers also did not have access to employment opportunities with potential for career progression, particularly in the higher wage segments of the economy, such as health care or manufacturing. The current economic crisis brings a new urgency to these labor market challenges, particularly for the low-skilled individuals competing for a shrinking number of jobs (Anderson, Holzer, &Lane, 2005).

Various experts subscribe to the notion that the severe recession that began in 2008 was the worst since the Great Depression of the early twentieth century. While this situation has had a negative effect on all social classes, it is especially grave for the lesser educated and the lower skilled job holders. Many of these low-skill jobs will not return, because of the transformation of both the American and the global economy (Friedman, 2005). One example of such restructuring is presented in the case of General Motors, where the bankruptcy and restructuring could cause the downsizing of the company by some estimates as much as 90% from its employment levels of the 1970s (Lasic & Bunkley, 2009).

The demand for highly trained and skilled labor is rising in the United States and the world, while the need for low-wage, low-skilled workers is in decline. One example is the trend for U.S. businesses to outsource the manufacturing of their products to low-wage countries (Gordon, 2005). Such outsourcing allows businesses to maximize their profits. According to the report *America's Forgotten Middle-Skill Jobs* (Holzer & Lerman, 2007), middle-skill jobs still make up approximately half of all employment today. In this report, the author defines middle-skill jobs as those that involve some noteworthy education and training beyond high school but less than a bachelor's degree.

The requirement for America to have more citizens with the technical skills and knowledge who will participate effectively in the workforce of the 21st century is becoming more evident. As a part of this need for a skilled and trained workforce, there is also the need for the workers to have access to skilled jobs. Warren (2000) reported when analyzing organizations' manufacturing needs in the United States that an inescapable focus occurs with employee education and training. Implementing new technologies is reliant on the proficiency of the individuals who use them. The capability to respond to rapid changes in world markets depends on workforces that can rapidly assimilate new assignments and roles by acquiring needed skills. When looking for solutions to issues related to training, many corporations have focused their attention on community colleges.

According to the report *America's Forgotten Middle-Skill Jobs* (Holzer & Lerman, 2007), for U.S. workers who do not complete some form of postsecondary education (certificate programs, associate's, bachelor's, graduate, and professional degrees) opportunities will become increasingly limited. Even more persuasive, however, is that occupations which previously required only a high school diploma now require levels of technical skills and knowledge that dictate advanced and continuing education. Students who continue their education beyond high school should realize clear economic benefits (National Center Education Statistics, 2001). The U.S. Bureau of Labor Statistics reported that in 2011 employees who did not finish high school earned $451 per week, whereas those with a high school diploma earned $638 per week. The Department of Labor also found that in 2011 a person with some college earned $719 per week, a person with an associate's degree earned $768 per week, and a person with a bachelor's degree earned $1,053 per week (U.S. Bureau of Labor Statistics, 2012). The U.S. Bureau of Labor Statistics also reported that the unemployment rate for those who attended college was significantly less than for those who did not. For employees who did not finish high school, the unemployment rate was 14.1%; employees with a high school diploma had an unemployment rate of 9.4%; and employees who had some college had an unemployment rate of 8.7%. The greatest differences occurred at the associate's degree level and the bachelor's degree level, where unemployment was 6.8% and 4.9%, respectively (U.S. Bureau of Labor Statistics, 2012).

Statement of Problem

There is a serious lack of literature to assist college academic managers in the development of career and technical education programs. Numerous peer-reviewed articles exist regarding the many aspects of a career and technical program, but a model does not exist to help the practitioner in the development of the program (Rojewski, 2002). The need for career and technical education was clearly expressed as early as 1964 (Doyle, 2011, p. 6)

According to Grubb (1999, para. 1), "In many ways postsecondary occupational education (PSOE) is a stepchild – even a stepchild of a stepchild. The institutions where it takes place – community colleges, technical institutes, some area vocational schools, other public training centers, private proprietary schools – are not well known and are often low status." Grubb declared that "in federal policy, these institutions are often afterthoughts: they do not benefit from the large programs aimed at K-12 schooling; and federal aid for vocational education, one of the few federal programs providing funding to both secondary and postsecondary programs, has always been written with secondary education in mind" (1999, para.1). Rojewski (2002) reported the need for the educational system to prepare workers for entry-level employment in the careers in the current labor market. Rojewski also expressed the need to focus federal funds on high schools and community colleges to be able to assist populations that are less likely to succeed in the labor force.

Research Question

The principal research question that directed this inquiry was:

What environmental conditions and organizational factors influence the nature of the strategic response in the form of technical education program development within community colleges?

To answer this overarching question five main subareas were developed:

- How are technical education programs developed in community colleges? How does the technical education development process differ within different community colleges? How does the technical education development process differ by the type of technical program being developed?

- How do differences in societal conditions; federal, state, and local governmental requirements; governing board requirements; and administrative actions in the regulative dimension influence the development of an institutional response in the form of technical education programs?

- How do the differences in program philosophy, public expectations, accrediting agency requirements, and student populations in the normative dimension influence the development of an institutional response in the form of technical education programs?

- How do the differences in the curriculum, instructional delivery, and student learning in the cultural-cognitive dimension influence the development of an institutional response in the form of technical education program?

- How do pressures that cause strategic responses, including the need for acquiescence, compromise, avoidance, defiance, and manipulation influence the development of an institutional response in the form of technical education program?

Conceptual Framework

The conceptual framework was derived from a review of the pertinent literature and was influenced by the work of Rojewski (2002). Rojewski's work, used as a basis, is intended as a jumping-off point. It suggests several dimensions that influence the environment of technical education development. Essentially, these dimensions of inspiration were examined according to resource dependency and institutional theories that envisage the nature of the processes, relationships, and environmental interactions (both external and internal) that embody the technical education development process.

The conceptual framework was then placed into an institutional theory framework. The context for this piece of the framework was addressed by Scott (2001) and Oliver (1991) and was used to refine this conceptual framework. The three institutional pillars: regulative, normative, and cognitive (Scott, 2001) and strategic responses (Oliver, 1991) were critical to the development of the conceptual framework. Focusing this study in this manner enables the researcher to build a case study that will spotlight the why and how things happen more than just if they happen. It will take advantage of the strengths of qualitative research methods to explore the data in a richer, more precise fashion.

The regulative pillar was defined by Scott (2001) as the overt regulative processes, for example, rule setting, monitoring, and sanctioning. It also includes the ability to institute rules, scrutinize or review others' compliance to them, and as needed, direct sanctions in terms of both rewards and punishment to sway future behavior. These processes may operate through informal means, for example, shaming and shunning activities, or the processes may be more formalized for example, through the police or courts.

The normative pillar is characterized by placing emphasis on normative rules that introduce a narrow, evaluative, and essential dimension into social life. Normative systems include both values and norms. Values are models of the ideal or the desirable together with the interpretation of standards to which existing structures or behavior can be compared and assessed. Norms specify how things should be done. Norms identify how things should be done and describe legitimate means to pursue valued ends. This pillar defines goals and objectives and the best way to pursue them (Scott, 2001).

The cognitive pillar emphasizes the importance of cognitive elements for institutions and the rules that compose the nature of reality and the structure through which meaning is made. Symbols (e.g., words, signs, and gestures) have an effect by shaping the meaning attributed to objects and activities (Scott, 2001).

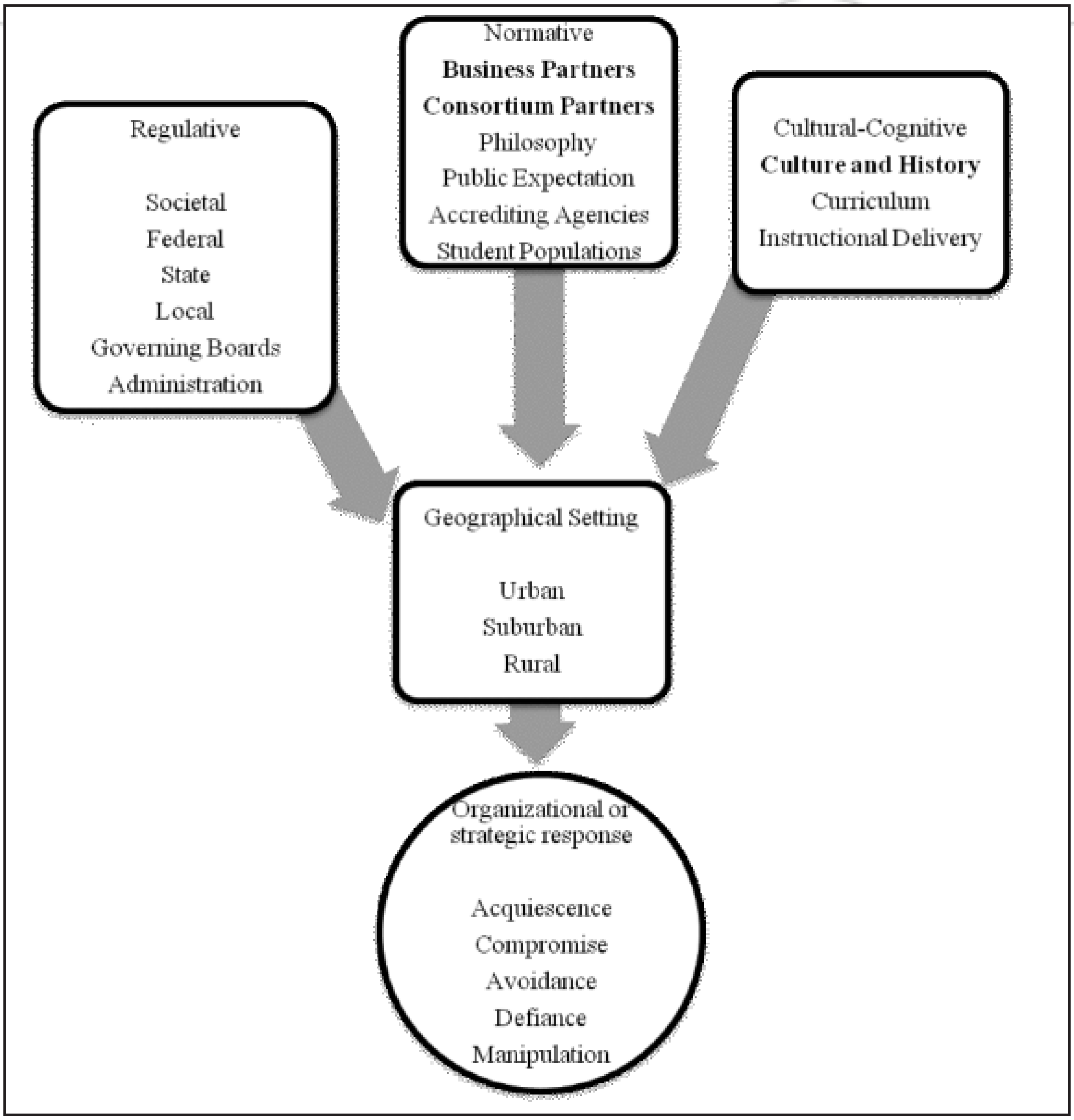

Figure 1. Revised Conceptual Framwork Guiding the Study of four Arkansas Community Colleges (Adapted from Rojewski, 2002 and Scott, 2001)

Method

The basis for this research was to examine the development of career and technical education programs in a community college using a qualitative case study approach. The conceptual framework was derived through a review of the literature, and it serves to focus and direct this study. The aim of the research is to assist decision makers in understanding both how Career and Technical Education (CTE) programs are developed and what makes them work. In order to achieve useful data, the researcher must stress to the participants to give open and honest answers that are more helpful than adulations and to abstain from providing signals of positive acceptance to feedback so that respondents will not be swayed to provide answers that would be perceived as positive.

Summary of the Study

This study was driven by one primary research question: What environmental conditions and organizational factors influence the nature of the strategic response in the form of technical education program development within community colleges? To answer this question, a qualitative study of four community colleges in the state of Arkansas was conducted. The organizations included the University of Arkansas Community College at Hope, Pulaski Technical College, National Park Community College, and Mid South Community College. These institutions, because of their geographical locations and student populations, were selected to represent the widest possible range of institutions.

A conceptual framework was developed that encompassed previous research on normative, regulative, and cultural-cognitive environments and organizational response processes. The framework, adapted from Rojewski (2002) and Scott (2001), served as a guide to identify how external conditions in the normative, regulative, and cultural-cognitive environments and organizational responses differently influence the nature of the development of programs.

Data were collected by interviews of administrators, division chairs, and instructors of technical programs from April 2010 to June 2010. Twenty-two individuals were interviewed. The interviews were recorded digitally, transcribed verbatim, and coded for analysis using the variables on normative, regulative, and cultural-cognitive environments and organizational responses from the conceptual framework. Documents and other archival data were used in combination with the interview data to describe and explain the factors that influence the occupational program development in the colleges.

Table 1. Participants of the study

Title	Participants
Vice-President or Vice Chancellor of Academics	4
Dean or Division Chair	6
Instructor	12

Review of Findings

This study presents a primary effort to scrutinize a key element in the occupational program development to determine how external conditions and internal organizational characteristics cooperate and combine to influence the nature of organizational response that manifests itself in the process of technical program development. Tentative evidence suggests that program development examined through the institutional response filters is a useful framework for explaining the development of technical programs. It also indicates that organizational characteristics play a fundamental part in the nature of the development of occupational programs.

Regulative Factors

Regulative factors play a major role in the development of all programs, including occupational programs. Each of these variables has a direct relationship with the institution and how the programs are developed. Some of these relationships are direct and some are consequential. For example, in most case study institutions, the administration involves students, faculty, staff, community members, and many others when developing the institutional strategic plans. From the strategic plans, the administration makes priorities for the institution and puts forth directives that program developers must follow.

The regulative variable the participants mentioned as having the most direct influence on the development of technical programs is the administration. The administration makes priorities for the institution, and it is the information exchange for most business and industry leaders. The priorities set by the administration provide resources, such as money to buy supplies or equipment, and employees to be able to work the program. From these priorities also spring many real properties like buildings, offices, classrooms, and laboratory space available for program use.

Each of the case study institution participants mentioned another major direct influence to occupational program development, the state government. The state governor meets with potential businesses and industries that want to locate within the state. These discussions can provide the institution with possible resources through the legislative system of the state. Another direct influence from the state government comes from the Arkansas Department of Higher Education (2005, p. 12). This Department initially influences a program through the guidelines it has established for the approval of a program. More directly, the Arkansas Department of Higher Education also influences development stages through the approval process, and if this Department wants to change a program, the program developer is asked to consider a change before it will be approved and the institution is allowed to offer the degree (Arkansas Department of Higher Education, 2005, p. 14).

The participants declared the variable with the most indirect influence is the federal government. Although the federal government provides some direct regulations or policies, most if its influence is provided in an indirect way in the form of money either to students or for programs. This influence provides the federal government with a very subtle mechanism to direct both programs and higher education institutions. Most higher education institutions could not survive without the students being able to obtain some federal financial aid. This one fact is paramount in the discussion and development phases of the program.

Normative Factors

The normative factors play a major role in the development of occupational programs. Each of the case study participants had many similar views about the normative factors, but there were interesting differences.

The case study participants listed similar traits when discussing philosophy and accreditation agencies. In the matter of philosophy, each participant mentioned the overarching philosophy of essentialism. In this study, essentialism was defined as a teacher-centered system, where the teacher takes the leadership role and sets the tone for the classroom. This philosophy is strengthened by the inclusion of an advisory committee and the ideas of the committee. Though most of the participants believed that the program should be a blend of all the educational philosophies and include the good traits from each one, they agreed that the main alignment occurred with essentialism.

The accreditation agencies are another variable about which the case study participants have agreed. The participants felt that the required accreditations must be accomplished. The participants thought it was also a good idea for programs to be included in the voluntary accreditation and match the requirements. When a program was built around the requirements of a voluntary accreditation agency, it made the accreditation a smoother process and the application and the subsequent accreditation yields a degree of instant credibility for the program.

The case study participants differed in their opinions of the impact of public expectations. The perception about the influence of public expectation ran the gamut between having very little influence on the development of a program and having an intense influence on the development of occupational programs and should be included in the model of occupational development.

Another disagreement occurred with the factor about the projected student population. Some of the participants believed that the projected student population played almost no role in deciding whether or not to develop a technical program. These participants thought it was incumbent upon the administration and the faculty, once the program was developed, to advise students how to get started in the program and how to handle any developmental course the student might need. Other participants mentioned the projected student populations did influence the development of occupational programs because to attract diverse students takes planning for their needs.

Cultural-Cognitive Factors

The case study participants held similar thoughts about the cultural-cognitive factors, especially the variable instructional delivery. Instructional delivery turned out almost unanimously in the response because the participants all mentioned that it was best to start a program in a classroom and get a glimpse how the program works as the faculty works through the curriculum with students in a classroom. This live teaching opportunity allows a faculty member to adapt the program to the students at hand, and it will provide important data to enable the faculty to provide the coursework in other media.

Although the participants agreed on the need for some basic curriculum subjects, they did not agree on how the student should receive those subjects. In some cases the research participant suggested that subjects like mathematics, English, or sociology should be contextualized in the technical coursework. Others suggested that these subjects should be taken from the college's normal array of courses, and the technical students should be a part of the typical college experience. For example, the mathematics requirement for all other programs is college algebra, and so the technical programs should also require it. During the interviews the majority of the participants mentioned that the curriculum for the program should include subjects that would enable students to further their degree plans and not be a hindrance to them. Most research participants felt that students who decided to continue their education should not be penalized by taking general education courses that would have to be repeated because these did not fulfill the degree requirements of future undergraduate degrees.

Findings

In addition to the basic findings of the conceptual framework, some additional issues emerged that have implications for program developers and other stakeholders. One significant finding related to the normative dimension is the population located around the college. The more urban the setting, the easier it becomes to develop and offer programs. The larger the population center the college is situated in, the larger the prospective pool of students that helps to bolster the requisite numbers to support the program. This finding illustrates the disparity between programs that are started in large population centers and those begun in smaller areas. This finding illustrates that rural and even suburban colleges can have difficulties with some programs finding requisite numbers of students that are needed and necessary for viability, but an urban college may not have trouble with attracting them.

Also a variable in the conceptual dimension geographic setting is college density. College density is the saturation of similar college degrees in a given geographical area (Doyle, 2011). This is exemplified by the city of Little Rock. The metropolitan area includes Little Rock, North Little Rock, Sherwood, Jacksonville, and Maumelle. There are over 583,845 people in the Little Rock area. The public colleges for Little Rock include Pulaski Technical College, University of Arkansas at Little Rock, and University of Arkansas Medical Sciences. The private colleges in Little Rock include Arkansas Baptist College, Philander Smith College, Remington College, and Webster University. This list does not include the numerous online colleges. This list yields four private colleges, three public colleges, a host of online colleges, and a multitude of specialty schools (e.g., beauty colleges, barber schools and many specialty trade schools). While there are several opportunities for students to attend postsecondary institutions, the overall college density is light. The result of this college density is a significant student enrollment over the last several years in beginning-level courses.

Program duplication is a dimension within college density. The term program duplication can be defined as saturation of similar competing college degree programs in a given geographical area. This competition would include a nursing program that awarded a diploma from an educational hospital, and a one-year practical nursing program at the local community college where a technical certificate was awarded.

A finding related to the normative dimension is the strength of a program when a business or industry partner is involved. Each partner adds a part to the program and helps the program to develop in a unique manner within that location. This kind of relationship with a business partner provides many opportunities for students, and these students spread the word about the outcomes and opportunities that the program afforded them. A program with a strong relationship to a business or one from which graduates are recruited by one industry will be seen as a gateway program to employment, and this helps to promote the program.

The addition of the variable consortium partners to the normative dimension was needed. The variable consortium partners is defined as the factors that deal with the interaction of the colleges as they work jointly to put career and technical programs together as a collective group. Consortium partners deal with multiple administrations, governing boards, communities (public expectation), and more. This variable also has an added factor in that students will transfer between member institutions, and this movement provides a new element to the relationship because programs must be comparable.

Discussion

During the interviews the participants held some reluctance about assigning characteristics from the strategic response dimension. This reluctance led the investigator to blend terms together to allow the participant a little more comfort with the terms. The terms acquiescence and compromise were seen as the same response just at different levels called negotiation resolution. Most participants viewed these terms as part of the negotiations that an institution goes through. This would define compromise as the working out a plan where both parties receive some benefit from the pact. Acquiescence would be defined as one party weighing the situation and determining the course of action required for this negotiation is to accept the other party’s method or plan. The terms avoidance and defiance were also seen as terms within a single variable that could be called policy disagreement. The definition the participants used for avoidance was if the procedure of not participating in a policy or regulation that was not formally adopted. Defiance was defined as the manner of working against a policy or procedure, to bring about change to the policy or procedure. This change in the policy or procedure was usually accomplished by means of working through the regulative body that issued the policy or procedure, but it may involve taking the issue to a court for a ruling.

Implications for Theory

This study contributes to organizational theory, specifically, in task environment and the organizational response. The environmental factors of normative, regulative, and cultural-cognitive dimensions adequately describe the task environment, but this study identifies one factor that influences what the institutions do to adjust themselves to carry on. This factor is geographical setting. Understanding the strengths and weaknesses of a college's geographical setting will allow the program developer to know how to begin an approach to the program development process. These strengths and weakness provide a set of boundaries for the administration when deciding which programs to begin. This study also identified the factor of business and industry partners. Business and industry partners provide the institution with insight into the career path that the college would not necessarily have.

Examining program development as Rojewski (2002) proved to be slightly problematic. The main discrepancy was in the sense of confidence the administrators had when approaching the development of a program. The addition of an environmental factor called geographic setting and the addition of the variable business and industry partnership in the normative dimension gave the study clarity and a more complete explanation of the development of technical education programs.

The strength of this study was the conceptual framework, which pulled together information from reputable theories. As mentioned, the framework demonstrated an effective lens through which to inspect the occupational program development process. It also made the cross-case comparisons on the environmental conditions and organizational response simpler and more understandable.

One closing thought relates to organizational response issues. Some of the variables held by organizational response were ones that participants were uncomfortable in attributing to their organization. For example, most of the participants, when first questioned about the variable avoidance, replied that their institution did not exhibit anything like this response. When pressed and given examples, the participants changed their answers and confirmed that their institutions did exhibit this response and gave examples from their institution. Another aspect of this concern is that most of the participants felt that the responses were part of the process, for example, an institution might exhibit avoidance until it was able to work out another solution that might fall into the variable of manipulation. So to the observer it was the process the institutions followed.

Suggestions for Future Research

This study was designed to be comprehensive in viewing the development of occupational programs in terms of normative, regulative, and cultural-cognitive dimensions and organizational responses. This study should be replicated in other states because Arkansas community colleges are relatively young in the history of higher education. This would verify the transferability of the results of the study of occupational program development to other institutions and states within similar context.

Another good addition to this scholarship would be to include the thoughts and views of state administrators, state two-year college association directors, and regional economic development directors. These individuals will have insights into the need for trained employees for businesses and industries and could help gather a more complete picture of the process of occupational development.

Finally, it would be good to address the development of occupational programs from a perspective of grouping according to matching as many descriptors as possible (i.e., rural community colleges, with student populations approximately the same size, and with similar programs). Holding these factors constant would provide for a more unified look at the colleges. This approach would allow the researcher to fully examine how each specific type of college develops occupational programs and would further aid the practitioners at those institutions.

Dr. Duane E. Doyle is an Assistant Professor of Mathematics at Arkansas State University-Newport

References

Acs, G., & Nichols, A. (2007). *Low-income workers and their employers: Characteristics and challenges.* Washington, DC: The Urban Institute

Andersson, F., Holzer, H., & Lane, J. (2005). *Moving up or moving on: Who advances in the low-wage labor market?* New York: Russell Sage Foundation.

Arkansas Department of Higher Education. (2005, October 22). Revision of criteria and procedures for establishing new certificate and degree programs and organizational units. Retrieved from Arkansas Department of Higher Education: http://www.adhe.edu/SiteCollectionDocuments/AcademicAffairsDivision/Criteria%20and%20Procedures%20for%20Preparing%20Proposals/BookAppNewProgramCriteriaandProceduresRevised2005.pdf

Doyle, D. E. (2011). Developing occupational programs: A case study of four Arkansas community colleges. *Dissertation Abstracts International 73*(02). (UMI No. 3481378)

Friedman, T. L. (2007). *The world is flat: A brief history of the twenty-first century.* New York: Farrar, Straus & Giroux.

Gordon, E. E. (2005). *The 2010 meltdown: Solving the impending jobs crisis.* Westport, CT: Praeger Publishers.

Grubb, W. N. (1999, August 11). *Evaluation of programs.* Retrieved from ED.gov: http://www.ed.gov/rschstat/eval/sectech/nave/grubbi.html

Holzer, H. J., & Lerman, R. I. (2007) *America's forgotten middle-skill jobs.* Retrieved from http://cos.edu/ImageUpload_Links/ForgottenJobsReport.pdf

Lasic, B., & Bunkley, N. (2009, April 27). G.M's latest plan envisions a much smaller automaker. *New York Times.* Retrieved from http://www.nytimes.com

Mishel, L., Bernstein, J., & Allegretto, S. (2005). *The state of working America, 2004/2005.* Ithaca, NY: Cornell University Press.

National Center Education Statistics. (2001). *The condition of education 2001.* Washington DC: Department of Education

Oliver, C. (1991). Strategic responses to institutional processes. *Academy of Management Review* 16 (1), 145-179.

Rojewski, J. W. (2002, February). *Preparing the workforce of tomorrow: A conceptual framework for career and technical education.* Retrieved from National Research Center Career and Technical Education: http://136.165.122.102/UserFiles/File/pubs/PrepWrkfrceAll_Rojewski.pdf

Scott, W. R. (2001). I*nstitutions and organizations.* Thousand Oaks, CA, Sage Publications.

U.S. Bureau of Labor Statistics. (March 12, 2012). *Education pays...* Retrieved from U.S. Bureau of Labor Statistics: http://www.bls.gov/emp/ep_chart_001.htm/

Warren, J. (2000). Collaboration between a small rural community college and a large industrial corporation for customized training. *Community College Journal of Research and Practice, 24*(8), 667– 679.