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Technological Literacy for All: A Course Designed to Raise the Technological Literacy of College Students

What is technology? If you were to ask someone to define technology, you have about a 75% chance of getting the answer of computers, electronics, and the internet (Rose, Gallup, Dugger, & Starkweather, 2004). This, however, is a far cry from what truly defines technology. The end result of our technological advances surrounds us. It is the car or bike we use for transportation to the toothbrush we use to clean our teeth. It is the process of building homes, roads, and products as well as agriculture, land development, and biotechnology. It is in our use of wood, metals, plastics, and concrete. Simply put, technology is everything we humans modify or make out of our natural environment to suit our needs. It can be formally defined as, "The innovation, change, or modification of the natural environment to satisfy perceived human needs and wants" (International Technology Education Association [ITEA], 2000, p. 7).

Understanding what technology is, and is not, is the first step in becoming technologically literate. One should also understand how technology is created, how it works, how it shapes society, and how society shapes technology (Garmire & Pearson, 2006). The importance of technological literacy cannot be understated. Our technological literacy influences one's occupational choices, health and economic well-being, choices for recreation, and political decisions. It also allows people to better understand and adapt to the ongoing, rapid changes in technological developments. According to the Committee on Technical Literacy (Pearson & Young, 2002):

> Technological literacy can provide a tool for dealing with rapid changes. A technologically literate person will find it easier to understand and assimilate new technologies and so will be less likely to be left behind. Equally important, technologically literate people will have a high enough comfort level and broad comprehension of technology to put the changes in context and accept them even if they do not fully understand them. (p. 44–45)

Due to the ramifications of having a technologically illiterate society in a time when technology is so pervasive, a call for increased technological literacy has been made by the National Science Foundation (Bloch, 1986), the American Association for the Advancement of Science (1993), and the International Technology and Engineering Educators Association (International Technology Education Association, 1996). Although the call for technological literacy is

Kimberly G. Baskette (kbaskett@odu.edu) is the Monarch Teach Program Coordinator at Old Dominion University and Todd D. Fantz (tfantz@regis.edu) is an Assistant Professor in the Department of STEM Education at Regis University

decades old, the teaching of technological concepts and processes continues to be limited within the K–12 educational system (Bybee, 2000). This study was designed to gauge the ability of a single-semester course to raise students' technological literacy as well as gains in student perceptions of the importance of technology education in the K–12 curriculum.

STEM 110T Course

Course Overview. The STEM 110T course, Technology and Your World, was developed through the Department of Science, Technology, Engineering, Mathematics, and Professional Studies as part of ODU's Lower Division General Education requirement. STEM 110T is one of thirteen courses offered that students may choose to take in order to fulfill ODU's *Impact of Technology* requirement. These courses are intended to "develop students' abilities to make reasoned judgments about the impact of technological development upon world cultures and the environment as well as upon individuals and societies" (Old Dominion University, 2009, para. 2). Through these courses, students are provided with an understanding of not only how technologies function but also their impact on society (Old Dominion University, 2009). The purpose of this study was to verify that the STEM 110T course is developing technological competencies outlined by the *Standards for Technological Literacy*. The research question guiding this study was: To what extent does the STEM 110T course at Old Dominion University affect the technological literacy of course completers?

Course Description. Eight sections of the STEM 110T course are offered each fall and spring semester with five sections scheduled during the day and two in the evening. An additional two to three sections are offered during the summer term. The sections are taught by a combination of PhD graduate students and adjunct faculty. Each section carries a maximum capacity of thirty students, and all sections typically fill each semester.

As per the 2011–2012 Old Dominion University catalog, the STEM 110T course is designed to provide students with:

> An overview of the resources, and systems of technology. Emphasis is on the impacts that technology has on individuals and their career. Discussion and activities explore the evolution of technology, its major systems and their impact on individuals and their careers (p. 297).

The purpose of the course is to assist each student in developing "critical and analytical thinking skills regarding the development, selection and use of technology" (Old Dominion University, 2012, p. 1). The course is designed to meet the following competencies as listed in the course syllabi (Old Dominion University, 2012).

A. Develop an understanding for the continuous evolution of technology and its impact on society, and the lives and careers of individuals.

B. Describe the progression of *energy, material, and information resources and their significance in human development.*
C. Describe the use and impact of *communication and information technologies.*
D. Describe the use and impacts of *physical technologies such as manufacturing, construction, transportation*.
E. Describe the use and impact of *biological and chemical technologies*.
F. Assess the limitations and impacts of technology on individuals, their careers, and society.
G. Forecast future developments in technological resources and systems.

The STEM 110T course is divided into seven major areas with each area focusing on a specific topic related to technology. Topics taught in this course are in alignment with ITEA's *Standards for Technological Literacy* and are as follows:

1. What is Technology?
2. The Problem Solving/Design Process
3. Producing Products and Structures
4. Communicating Information and Ideas
5. Transporting People and Cargo
6. Energy and Progression
7. Bio-related Technologies

The STEM 110T course utilizes a variety of instructional techniques (e.g. lectures, class discussions, class activities, assignments, and projects) to disseminate knowledge of technology and its impact on students' lives, careers, and society as a whole. Instructional activities are also designed to assist students in the development of 21st century skills (i.e. communication, collaboration, creativity, critical thinking, and problem solving).

Methodology

The 2001 and 2004 ITEA Gallup Poll surveys were developed as a collaborative effort between ITEA and Gallup (Harrison, 2009). The original intent of the 2001 survey was to assess the general public's perceptions of technology and technological literacy in the United States (Rose, Gallup, Dugger & Starkweather, 2004). The survey was modified in 2004 with the intent remaining consistent with that of the 2001 poll. All survey questions were developed based on ITEA's *Standards for Technological Literacy*, thus establishing the content validity of the instrument (Harrison, 2009). According to Volk & Dugger (2005), reliability data showed the 2001 and 2004 ITEA Gallup polls to have "maintained a 95% confidence level with a margin of error set at plus or minus four percentage points" (p. 57). Reliability was further established as the 2001 and 2004 surveys showed similar results leading the researchers to derive the same three major conclusions, regardless of the three-year time lapse, as shown below:

- The public understands the importance of technology in our everyday lives and understands and supports the need for maximizing technological literacy.
- There is a definitional difference in which the public thinks first of computers when technology is mentioned, while experts in the field assign the word a meaning that encompasses almost everything we do in our everyday lives.
- The public wants and expects the development of technological literacy to be a priority for K–12 schools. (Rose et al., 2004)

A pre–post survey study was conducted during the spring 2012 semester at ODU to assess gains in the technological literacy of students enrolled in the STEM 110T course. A convenience sample of students from all eight STEM 110T sections, taught by three PhD Graduate Assistants and two Adjunct faculty members, was surveyed at the beginning and end of the semester. The survey instrument included a combination of questions from the 2001 and 2004 ITEA Gallup Poll surveys. One question from the 2004 survey, deemed not pertinent due to outdated technology, was omitted from the original survey, and questions from the 2001 survey not included in the 2004 survey were added. The survey consisted of 24 questions, 23 of which were forced response items which used a combination of 4-point Likert scales, dichotomous yes–no questions, and multiple-choice questions. One item was an open-ended question. In addition, seven demographic questions were included to collect information regarding the students' gender, age, ethnicity, employment history in a technological field, year in school, enrollment status, and major.

At the beginning of the spring 2012 semester, a total of 287 students were enrolled in the STEM 110T course. To ensure a high return rate, surveying took place in each of the STEM 110T classes during the first and last weeks of the semester. The researchers visited each of the classes and were responsible for explaining, distributing, and collecting the surveys. The researcher remained in the class during the data collection process, and surveys were collected upon completion. The STEM 110T instructors were not given access to the survey during the study nor did they have any participation in the data collection process.

This study had several limitations that the reader should consider when analyzing the results. The research took place at one higher education institution located in the Southeast United States; therefore, the results may not reflect other institutions or geographic locations. The survey instrument used in this study asked perception questions instead of knowledge questions. A self-perceived development of technological literacy may not accurately indicate one's true literacy. The students involved in this study were concurrently enrolled in other courses at the university, which may have enhanced or hindered the technological literacy of the participating students.

Results

In total, 230 pre-surveys were completed and returned at the start of the semester and 204 post-surveys at the end, giving return rates of 93% and 84%, respectively. Attrition from the course contributed to the decrease in the number of post-surveys collected. Pre- and post-survey data were manually inputted into Excel spreadsheets; questions left blank or with answers not clearly delineated were not included. A paired samples t-test was run on the mean scores from the Likert scale questions to determine if there were significant differences between the STEM 110T students' pre- and post-survey responses. The major themes from the 2004 Gallup survey results were used to code student responses to the open-ended item; additional themes were added that emerged from the post-survey results. Frequency data was computed for the open-ended, dichotomous scale, and multiple-choice response questions. Significant results from the survey data are discussed below.

Demographics

For the purposes of this study, descriptive statistics, shown in Table 1(next page), were calculated for gender, ethnicity, age, and year in school. As the data shows, the percentage of females (61%) enrolled in the STEM 110T course exceeded that of males (38%). This gender gap is consistent with the current enrollment of males and females in higher education. According to the National Center for Education Statistics (2010), the percentage of females enrolled in degree-granting institutions in the United States in fall 2009 was 57%, as compared to 43% of males. Eighty-nine percent of the study participants fell within the 18–22 age range, the typical range of most college students. Although whites made up approximately 60% of the study population, approximately 25% of the population was African American. The multiracial category had the third highest representation comprising 7.0% of the population with Hispanics (≈1.7%), Asians (≈3.0%), Asian/Pacific Islanders (≈1.1%), and Native Americans (≈0.7%) representing the remainder of the study population. Although STEM 110T is a lower-level general education course, only 57% of the study population were freshmen and sophomores. Many underclassmen, for a variety of reasons, choose to wait to take the STEM 110T course until their junior or senior year, thus accounting for the large percentage of upperclassmen enrolled in the course.

Table 1
Demographics

Demographic	Pre-Survey (%)		Post-Survey (%)	
Gender	Male	37.8	Male	38.2
	Female	61.3	Female	60.8
Age (yrs)	18-19	43.9	18-19	31.4
	20-22	44.9	20-22	57.8
	23-26	6.5	23-26	5.4
	27-29	1.3	27-29	2.5
	30-49	3.0	30-49	2.5
Ethnicity	White	58.7	White	60.8
	African American	25.2	African American	24.5
	Hispanic	3.5	Hispanic	2.0
	Asian	2.2	Asian	3.9
	Asian/Pacific Islander	1.7	Asian/Pacific Islander	0.5
	Native American	0.4	Native American	1.0
	Multiracial	7.0	Multiracial	6.9
Year in School	Freshman	11.3	Freshman	11.3
	Sophomore	45.2	Sophomore	47.1
	Junior	23.9	Junior	23.5
	Senior	17.4	Senior	17.6

Concept of Technology

Questions in the survey directed at assessing the students' concept of technology showed that completing the STEM 110T course was positively correlated with their concept of technology. In an open-ended format, students were asked, "When you hear the word *technology*, what first comes to mind?" Ideally, it is understood that technology encompasses much more than just computers and the Internet. Provided in Table 2 is a complete list of responses which indicate increased technology literacy among the STEM 110T students. Results demonstrated that the STEM 110T course impacted students' thinking of what technology means, as 26% of students on the post-survey indicated they first think of "computers" when they hear the word *technology* as compared to 38% on the pre-survey (Table 2). In addition, a decline was observed in the number of students noting electronics and cell phones on the post-survey, 12% and 11%, as compared to the pre-survey, 5% and 6%, respectively. These are significant findings because computers, electronics, and cell phones have an increased presence in students' lives, resulting in them oftentimes being their first line of thinking in relation to technology.

Items on the post-survey also indicated a more holistic view of technology, as compared to the pre-survey. As Table 2 (next page) shows, a significant increase was seen in the number of students on the post-survey (15%) who responded with the statement "Anything that makes tasks/life easier/better," as compared with the pre-survey (3%). Other responses worth noting which emerged on the post-survey included, “everything in the modern world.” “improvements in life and the modern world.” “man-made creations and enhancements to answer needs of mankind,” and “changing the world.”

Table 2
When Your Hear the Word Technology, What First Comes to Mind?

Survey Responses	% Mentioned Pre-Survey	Post-Survey
Computers	38	27
Electronics	12	5
Cell Phones	11	6
Advancement	7	7
New Inventions	3	2
Machines/Machinery	3	3
Health/Medicine	1	3
Anything that makes tasks/life better/easier.	3	15
Everything in the modern world.	N/A	6
Improvements in life and the modern world.	N/A	5
Manmade creations to answer needs of mankind.	N/A	4
Changing the world.	N/A	2

When asked on a 4-point scale ranging from 1 for *not at all important* to 4 for *very important*. how important it was for people to be able to understand and use technology, no significant difference was found between the pre-survey (M = 3.83, SD = 0.481) and post-survey results (M = 3.86; SD = 0.364); $t(203) = -0.687$, $p \geq 0.05$). These results indicate that, on average, the STEM 110T students, regardless of their technological literacy level, entered the course with the opinion that it was very important for people to understand and use technology.

To further assess understanding of technology, the students were presented with two definitions of technology and were asked which they felt more closely fit their thoughts upon hearing the word *technology*. On the pre-survey, 67% of the students selected the definition “computers and the internet,” but the post-survey results showed 72% selected “changing the natural world to satisfy our needs” (Table 3, next page). These results clearly show the impact of the STEM 110T course in altering the students’ thought process in terms of how they define technology.

Table 3
Given the Following definitions, Which of the Following More Closely Fits What You Think of When You Hear the Word "Technology"?

Statements	Pre-Survey (%)	Post-Survey (%)
"Computers and the internet"	67.2	32.8
"Changing the natural world to satisfy our needs"	27.0	72.1

The final question used to assess understanding sought to determine what the students were more likely to think of when hearing the word *design* used in relation to technology. The results showed a minority (40.2%) of the STEM 110T students thought of *design* as "a creative process for solving problems" on the pre-survey, while a majority (58.8%) believed *design* to be "blueprints and drawings from which you construct something." By the end of the semester, 58.8% of the students thought of *design* as being "a creative process" as shown on the post-survey results (Table 4). This 16.6% gain with viewing *design* as a "creative process for solving problems" is significant as it is in alignment with the *Standards for Technological Literacy* (Rose & Dugger, 2002).

Table 4
Which of the Following Are You More Likely to Think of When You Hear the Word "Design" Used in Relation to Technology?

Statements	Pre-Survey (%)	Post-Survey (%)
"A creative process for solving problems."	40.2	64.7
"Blueprints and drawings from which you construct something."	58.8	34.8

Impact of Technology

Understanding the impact technology has on society as a whole is an important part of technological literacy. Several statements were presented to assess the students' views on the impact of technology on society. For each statement, the students were asked, on a 4-point Likert scale ranging from *Strongly Disagree* to *Strongly Agree* to determine the extent to which they agreed or disagreed with each statement. As the results in Table 5 show, on average, the students disagreed with the statement "Technology is a small factor in your everyday life" to a greater extent on the post-survey (M = 1.53, SD = 0.601), as compared to the pre-survey (M = 1.67, SD = 0.915); $t(201) = 2.011$, $p \leq 0.05$). When presented with the statement "Engineering and technology are basically one and the same thing." the post-survey results (M = 2.26, SD = 0.809) showed a higher level of disagreement, as compared to the pre-survey (M = 2.47, SD = 1.020); $t(200) = 2.148$, $p \leq 0.05$). Although no significant difference was observed between the mean score of the pre-survey (M = 2.34, SD = 0.801) and post-survey (M = 2.40, SD = 0.871); $t(193) = -0.653$, $p \geq 0.05$), responses to the statement "Science and technology are one and the same." the results suggested that the students, on average, entered into the course with an understanding that a difference exists between them. These results demonstrate knowledge of technological literacy, as the students understand that although science, technology, and engineering are interrelated and depend on each other, they are separate entities. With the current emphasis on STEM in global education, it is important that people understand a distinction exists between not only engineering and technology but also science and technology. This course appears to have a vital role in students' acquisition of this delineation.

As shown in Table 5 (next page), post-survey results (M = 3.04, SD = 0.702) showed a higher level of agreement to the statement "Most environmental problems can be solved using technology," as compared to the pre-survey (M = 2.64, SD = 0.682); $t(196) = -5.757$, $p \leq 0.05$). The students, on average, were also found to agree more with the statement "Design is a process that can be used to turn ideas into products" on the post-survey (M = 3.51, SD = 0.610), as compared to the pre-survey (M = 3.35, SD = 0.607); t (198) = -2.689, $p \leq 0.05$).

Table 5
To What Extent Do You Agree or Disagree With the Following Statements Regarding Technology?

Statements	Pre-Survey		Post-Survey	
	M	*SD*	*M*	*SD*
"Technology is a small factor in your everyday life"	1.67	0.602	1.52	0.915
"Engineering & technology are one & the same"	2.47	1.020	2.26	0.809
"Science & technology are one & the same"	2.34	0.801	2.40	0.871
"Most environmental problems can be solved using technology"	2.64	0.682	3.04	0.702
"Design is a process that can be used to turn ideas into products"	3.35	0.607	3.51	0.610

Interest in Technology

Study results indicate that as students' technological literacy levels increased, so did their awareness and interest in the development and use of technology. Although the mean score on the pre-survey (M = 3.47, SD = 0.716) indicated that the students, on average, came into the course feeling it was important to know how various technologies work, there was a significant increase in the level of importance on the post-survey (M = 3.64, SD = 0.521); $t(198) = -2.749$, $p \leq 0.05$). As Table 6 (next page) demonstrates, results indicated that students felt it was more important to understand whether it was better for a product to be repaired or thrown away on the post-survey (M = 3.66, SD = 0.621), as compared to the pre-survey (M = 3.47, SD = 0. 763); $t(199) = -2.487$, $p \leq 0.05$). No significant difference was seen in the level of importance students placed on "being able to develop solutions to a practical technological problem" between the pre-survey (M = 3.37, SD = 0.798) and post-survey (M = 3.50, SD = 0.758); $t(198) = -1.617$, $p \geq 0.05$) (Table 6). However, as the mean scores show, responses to this statement indicated a higher level of importance being placed on having the ability to develop solutions to technological problems at the end of the semester. Responses to the aforementioned questions were on a 4-point Likert scale ranging from *Not at all important* to *Very important*.

Table 6
How Important Is It to You, Personally, to Know Each of the Following?

Statements	Pre-Survey		Post-Survey	
	M	*SD*	*M*	*SD*
Knowing whether it is better to repair products or better to throw them away.	3.47	0.763	3.66	0.621
Being able to develop solutions to a practical technological problem.	3.37	0.798	3.50	0.758

In the technological areas of "modification of plants and animals to supply food" ($M = 2.48$, $SD = 1.052$; $M = 2.82$, $SD = 0.1.007$), "robotics and other technologies in manufacturing" ($M = 2.58$, $SD = 0.950$; $M = 2.83$, $SD = 0.983$), and "new construction methods for homes and buildings" ($M = 2.69$, $SD = 0.997$; $M = 2.94$, $SD = 0.993$), student interest level was found to significantly increase between the pre-survey and post-survey ($t(201) = -3.259$, $p \leq 0.05$; $t(201) = -2.644$, $p \leq 0.05$; $t(200) = -2.412$, $p \leq 0.05$), respectively (Table 7). No significant difference was found between the pre-survey ($M = 2.83$, $SD = 1.089$) and post-survey ($M = 2.83$, $SD = 1.052$; $t(199) = -0.769$, $p \geq 0.05$) for interest in the technological area of "space exploration" (Table 7). When asked how informed they felt about the aforementioned technological areas, students indicated that they felt more informed at the end of the course, as compared to the beginning, in all four technological areas: "modification of plants and animals to supply food" ($t(201) = -9.016$, $p \leq 0.05$), "robotics and other technologies in manufacturing" ($t(201) = -9.423$, $p \leq 0.05$), "new construction methods for homes and buildings" ($t(201) = -9.351$, $p \leq 0.05$), and space exploration ($t(201) = -5.006$, $p \leq 0.05$) (Table 8). As the results showed, although the students did not show an increased interest in space exploration, the course did increase their level of understanding (Table 8, next page).

Table 7
How Much of an Interest Do You Have in the Following Topics?

Statements	Pre-Survey		Post-Survey	
	M	*SD*	*M*	*SD*
Modification of plants and animals to supply food.	2.48	1.051	2.82	1.008
Robotics and other technologies in manufacturing.	2.58	0.949	2.83	0.983
New construction methods for homes and buildings.	2.69	0.997	2.94	0.993
Space exploration.	2.83	1.090	2.91	1.052

Table 8
How Informed Do You Feel About the Following Topics?

Statements	Pre-Survey *M*	Pre-Survey *SD*	Post-Survey *M*	Post-Survey *SD*
Modification of plants and animals to supply food.	2.06	0.947	2.90	0.864
Robotics and other technologies in manufacturing.	1.93	0.776	2.73	0.923
New construction methods for homes and buildings.	1.97	0.828	2.79	0.862
Space exploration.	2.13	0.874	2.59	0.884

An additional question worth noting sought to determine the students' attitude towards the various forms of technology used in everyday life. Although a significant difference was not found, 73% of the STEM 110T students on the pre-survey and 78.9% on the post-survey indicated they "would like to know something about how it works" (Table 9). In contrast, 26% on the pre-survey and 20.1% on the post-survey responded that they "don't care how it works just as long as it works" (Table 9). Although these results are positive, they are also somewhat troubling because approximately one-fourth of the students indicated, at the conclusion of the course, little to no interest in knowing how technologies work.

Table 9
Which of the Following Statements Best Describes Your Attitude Towards the Various Forms of Technology You Use in Your Everyday Life?

Statements	Pre-Survey (%)	Post-Survey (%)
You don't care how it works just as long as it works.	26.0	20.1
You would like to know something about how it works.	73.0	78.9

Technology and Education

Due to the increased focus on STEM in K–12 education, the survey included questions that assessed the importance of high school students having an understanding of the various technological areas. Respondents were presented with several items to which they were asked to rate importance on a 4-point Likert scale ranging from 1 for *Not at all important* to 4 for *Very important*. As demonstrated in Table 10 (next page), the post-survey results (*M* = 3.48, *SD* = 0.658) showed the STEM 110T students felt it was more important for high school students to understand "the relationship between technology, mathematics & science," as compared to results from the pre-survey (*M* = 3.38, *SD* = 0.816; $t(200) = -2.758$, $p \leq 0.05$). The STEM 110T students, on average, also assigned a higher level of importance for high school students to have an understanding of the "relationship between technology and the economy" (*M* = 3.37, *SD* = 0.816; *M* = 3.59, *SD* = 0.658), the "relationship between technology and the environment" (*M* = 3.47, *SD* = 0.693; *M* = 3.62, *SD* = 0.646), and "the role of individuals in the development & use of technology" (*M* = 3.47, *SD* = 0.708; *M* = 3.29, *SD* = 0.720) on the post-survey, as compared to the pre-survey ($t(200) = -2.758$, $p \leq 0.05$; $t(200) = -2.253$, $p \leq 0.05$; $t(199) = -2.530$, $p \leq 0.05$) (Table 10). Although the mean scores on the pre-survey indicated the STEM 110T students, on average, felt it was important for high school students to understand the "overall effect of technology on our society" (*M* = 3.61, *SD* = 0.640) and the "relationship between technology, mathematics & science" (*M* = 3.33, *SD* = 0.807), no significant difference was observed between the pre-survey and post-survey results (*M* = 3.62, *SD* = 0.661; $t(199) = -0.245$, $p \geq 0.05$; *M* = 3.45, *SD* = 0.780; $t(200) = -1.535$, $p \geq 0.05$) (Table 10).

Table 10
How Important Do You Feel It Is That High School Students Are Able to Understand and/or Do the Following?

Statements	Pre-Survey *M*	Pre-Survey *SD*	Post-Survey *M*	Post-Survey *SD*
The relationship between technology and the economy.	3.38	0.816	3.59	0.658
The overall effect of technology on our society.	3.61	0.640	3.62	0.661
The relationship between technology and the environment.	3.47	0.693	3.62	0.646
The relationship between technology, math & science.	3.33	0.807	3.45	0.780
The role of individuals in the development & use of technology.	3.29	0.720	3.47	.708

When asked whether the study of technology should be a required or optional subject in high school, 66.2% of the STEM 110T students on the post-survey felt it should be required, as compared to 33.8% on the pre-survey (Table 11, next page). In addition to technology being a required subject, the mean scores, as shown in Table 12, demonstrated that the STEM 110T students felt it was more important at the end of the course for high schools to prepare students in the following technological areas: the "relationship between technology, math & science (M = 2.90, SD = 0.918; M = 3.24, SD = 0.828), the "role of people in the development & use of technology (M = 2.84, SD = 0.804; M = 3.23, SD = 0.815), "knowing something about how products are designed" (M = 2.68, SD = 0.892; M = 3.16, SD = 0.845), "the ability to select and use products" (M = 3.20, SD = 0.824; M = 3.44, SD = 0.743), and "understanding the advances and innovation in technology" (M = 3.04, SD = 0.796; M = 3.41, SD = 0.749). Significant differences were found between the results on the pre-survey and post-survey for all five technological areas ($t(196) = -3.896$, $p \leq 0.05$; $t(197) = -4.293$, $p \leq 0.05$; $t(197) = -5.336$, $p \leq 0.05$; $t(197) = -3.038$, $p \leq 0.05$; $t(195) = -4.699$, $p \leq 0.05$).

Table 11
Should the Study of Technology Be a Required Subject in High School or Should It Be Optional?

Statements	Pre-Survey (%)	Post-Survey (%)
Technology should be a required subject.	46.1	66.2
Technology should be an optional subject.	52.9	33.8

Table 12
How Important Is It for Schools to Prepare Students in the Following Areas?

Statements	Pre-Survey		Post-Survey	
	M	***SD***	***M***	***SD***
The relationship between technology, mathematics & science.	2.90	0.918	3.24	0.828
The role of people in the development & use of technology.	2.84	0.804	3.23	0.815
Knowing something about how products are designed.	2.68	0.892	3.16	0.845
The ability to select and use products.	3.20	0.824	3.44	0.743
Understanding the advances and innovations in technology.	3.04	0.796	3.41	0.749

The results presented in this section clearly illustrate the impact of the STEM 110T course in not only improving technological literacy levels at the post-secondary level but also raising awareness of the importance for an increased focus on technology at the high school level.

Discussion

Citizens need to be technologically literate in order to succeed and thrive in our increasingly technological global society (Garmire & Pearson, 2006). Old Dominion University, similar to other institutions, has responded to this need by requiring a technology component to be included within the general education graduation requirements. STEM 110T, one of thirteen courses that students may choose to take to meet ODU's "Impact of Technology" general education requirement, seems to have achieved its intended goal on many fronts but still has room for improvement on others.

The course appears to be giving students a greater understanding of what aspects make up technology. Based on pre–post testing, completers of the STEM 110T course gained a better understanding that technology is more than just computers. This is demonstrated through the open-ended responses to "When you hear the word *technology*, what first comes to mind?" The STEM 110T students were more likely to view technology as being narrowly defined as computers and electronics at the beginning of the semester as compared to the end. Further evidence of this increased technological literacy was shown through students using statements such as "everything in the world" and "manmade creations" when defining technology on the post-survey. It should be noted, however, that computers were still the top response of students who completed the course. As a result, the course could benefit from adding more content around the general definition and practical examples of technology throughout history. Ideally, by the end of the semester , the students perception of technology would be more closely aligned with the "innovation, change, or modification of the natural environment to satisfy perceived human needs and wants" (ITEA, 2000).

An interesting result from this study came from what the STEM 110T students believed high school students should be able to understand and do with technology. The number of students who believed technology should be a part of the high school curriculum grew from 46.1% to 66.2% following completion of the course. The STEM 110T students believed that high school students should not only be taught how to select the best product but should also be technologically aware of how products are developed. In addition, it was felt that high school students should have an understanding of the interrelationships between technology and such areas as math, science, the environment, and the economy. Producing a citizenry that values technology education will help insure its pivotal role in K–12 STEM education. These results indicate that STEM 110T completers would be more likely to favor a strong presence of technology education in the curriculum. Therefore, we can assume they would encourage future generations to enroll in technology education electives as well as vote for initiatives that favor technology education development in K–12 schools.

One of the more exciting results of the study was the gain in interest in technology following completion of the course. A greater majority of the STEM 110T students showed an interest in food and animal modification technologies, robotics, and construction industries. Recent concerns about the United States' falling behind in technological advancements have led to a call for more home-grown technologists. This course appears to be beneficial in exposing students to possible technological career areas they might not otherwise have known about.

The STEM 110T course seems to be making strides in developing technological literacy. Completers of the course have a better understanding of the definition of technology and have shown increased attributes in certain areas involving technological literacy. However, more can be done to increase all aspects of technological literacy. Students still need to develop the want and need to understand how technology works, how it is created, how it shapes society, and how society shapes technology. This is a tall demand for a one-semester course. The researchers, however, are optimistic that the results of this study are an indication that gains in technological literacy can be achieved through a one-semester technology course utilizing real-world problems and situations.

Applications and Future Research

The results from this study may aid other institutions interested in developing courses that are specifically designed to raise technological literacy. The course layout and designated topic areas were designed around the *Standards for Technological Literacy* and seem to have an impact on students understanding and interest in technology. Efforts should be made to include content that emphasizes the global impact of technological literacy and the need to understand how it was developed, how it works, and how it shapes society and individuals.

The researchers hope to use the results from this study to implement minor changes in the STEM 110T course curriculum. Longitudinal effects will be analyzed utilizing the same survey instrument over the next several semesters of the course offering. As STEM 110T is just one of the many technology courses taught as part of the technological requirement for ODU graduates, future studies of other course impacts will be necessary to gain a more holistic view of how well ODU is reaching its technological literacy goals. As technology continues to evolve, so does our need to acquire an understanding of it. Teaching about technology's role in our society is one method of providing technological literacy to the future leaders and decision makers in the United States. Old Dominion University's STEM 110T course appears to be making strides in providing meaningful technological literacy to its student population and will hopefully assist in producing technologically literate graduates capable of navigating the 21st century and beyond.

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Physical Learning Environment and its Suitability to the Objectives of Technology Education

In Estonian educational reform, the National Curriculum for Basic Schools, adopted in 2011, plays an important role and, among other subjects, sets new directions for technology education. The school bears the responsibility for creating a learning environment that is based on modern skills and knowledge and facilitates students' understanding of the world of technology. In Estonian general education schools, the subject of Technology Education is first introduced in Grade 4, when students are 10 to 11 years old. Before that period (in Grades 1–3) the main focus is on Handicraft and producing various objects, whereby Handicraft skills are valued and students learn about Estonian culture and traditions.

For the first time the new curriculum describes the study environment of Technology Education, which is seen as a community of intellectual, social, and physical environment:

> Learning environment is regarded as the ensemble of the intellectual, social, and physical environments where students develop and learn. The learning environment supports the student's development into an independent and active learner, carries the basic values of basic education and the school's mental attitude, and preserves and refines the traditions of the region and the school community. (Põhikooli riiklik õppekava, 2011)

Thus, the learning environment creates prerequisites and conditions for acquiring a subject as well as for the development of the student's personality. Technology Education is established on performing various practical tasks mostly in a material-spatial environment. The material basis of teaching carries an important role, comprising both the aids for teaching (literature, didactic teaching materials, tools etc., technical teaching aids, and their software) as well as the material-spatial conditions where the teaching is carried out (classrooms, workshops, labs, and the equipment). The curriculum for Technology Education establishes the standards of the physical learning environment the school is required to provide. The school predominantly teaches Technology Education in classrooms, which are equipped according to the practical work selected by the school, and the schools provide the materials necessary for teaching Technology Education (Ainevaldkond "Tehnoloogia," 2011). In this article terms *physical learning environment* and *material-technical basis* are used as synonyms.

The curriculum establishes minimal requirements for the physical learning environment of Technology Education. The school is free to upgrade the list of rooms and equipment according to the work plan developed by the teacher,

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Mart Soobik (mart@tehnoloogia.ee) is a doctoral student in the Department of Educational Science, Institute of Educational Sciences, University of Tallinn
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which includes both the learning tasks to be carried out during the lessons as well as practical work. In addition to the national curriculum, the regulations "Health-protection requirements for schools" (Tervisekaitsenõuded koolidele, 2012) drawn up by the Ministry of Social Affairs prescribe specific (including technical) requirements for Technology Education.

The requirements and suggestions regarding the physical environment of teaching Technology Education are not always realised in practical teaching. This may be due to a variety of reasons; for example, the lack of financial means for creating a modern physical learning environment, teachers' insufficient knowledge of the objectives of modern Technology Education, the importance of the subject not being sufficiently emphasised in school, etc.

The purpose of the present article is to explain the disagreement between the requirements established in the National Curriculum for Basic Schools for the physical environment of teaching Technology Education and the actual state in the schools today. The article gives an answer to the following questions:

1. To what extent are teachers satisfied with the material-technical basis of Technology Education?
2. What methods and conditions of material-technical basis would guarantee the expected standards for Technology Education?

The objective of the present article is to examine and compare the opinions of teachers in Estonian basic schools on the material-technical basis in light of both the present (since 2011—Technology Education) and the previous (from 2002 to 2011—Craft and Technology Education) curriculum.

Theoretical Background

Changes in the Objectives and Content of the Subject

Over the years the objectives and the content of the subject have changed considerably. The changes are not merely connected with Estonia, but are due to global changes in the development of technology in the world as a whole. Vries (2011) argues that the concept of Technology Education widened; we began to understand that technology has a social embedding, a human dimension, and it has gone through a certain history. Parikka, Rasinen, and Ojala (2011) give their view of contemporary technology education:

> During technology classes understanding of the relation between technology and culture, technology and society, technology and nature and the effects of technology on these should be discussed and understood. This means a conscious, critical and reflective attitude towards technology. Education becomes more meaningful and diverse when an open analysis is conducted about the values and lifestyles - the concept of humanity and the world - that the technological way of life is based on, and where the choices will lead to…. This in turn will challenge the pupils to consider

> development trends offered by future technology and to take more responsibility for their own curriculum and work. (p. 136–137)

Teaching Technology Education at school should be planned and organised in a way that would stem from the vision of different possibilities in future life (Parikka 2003). It would be a future-oriented education, the goal of which would be technological readiness, which helps today's students and future adults to make ethically sustainable choices on technological commodities, use these resourcefully, and develop technological solutions that are more practicable and less harmful to the environment (Parikka, 1998).

Technology Education tries to explain the structure and the principles of operation of the human-shaped technological world to students (Parikka & Rasinen, 2009). Alamäki (2000) stresses that it is very important for technological invention that students are able to identify and notice problems that can be solved with the help of technological solutions; in this process, they need to be able to reason if the problem is in the connection with the technological world and what kind of technologies they could use in solving certain problems. Järvinen, Karsikas, & Hintikka (2007) advocate that children's understanding of technology can be achieved by enabling them to work in the same spirit that real technologists do. In addition to the perspective above, children should be given opportunities to act according to the technological processes required to solve the problems they face (Twyford & Järvinen, 2000). As part of general education, engaging pupils in designing and making products of worth in ways that develop creativity, problem-solving skills, and the ability to collaborate is a demanding task (Barlex, 2007).

Engineering and Technology Education provide an outstanding environment for activating these clearing processes in the classroom for several reasons. Learning, engineering, and technology take place in a rich and sophisticated learning environment, consisting of materials, tools, machines, and computers (Barak, 2011). Children need to be given opportunities for creative and innovative action. In addition to tools, materials, and other physical resources, other people's ideas are an additional resource to inform individual learning (Banks, 2009). Ritz and Moye (2011) write that:

> Teachers of Engineering and Technology Education need to provide environments where appropriate content is taught and experiences allow students to apply and test the knowledge gained. After positive experiences with the new knowledge, learners gain ownership of the knowledge and can then use it to solve problems and answer questions. This type of mastery experience is the basis for the design experiences that occur in engineering and Technology Education laboratories – learn it – apply it – master the experience – transfer the knowledge to new situations. (p. 132)

The Importance of Practical Activities in Technology Education

In Technology Education, learning is mostly achieved through different practical tasks. Rasinen (2011) stresses that Technology Education should be studied, whenever possible, through practical, hands-on activities. To make this happen, learning should take place in a modern learning environment, in which modern learning methods are applied, with teachers who interpret handicraft education in a modern and future-oriented manner (Rasinen, 2011). All students need a basic understanding of how physical materials and processes are produced and applied, and many learn best when they are given frequent opportunities to make the abstract concrete (Hill, 2006). Learning through experimentation and practice is important for motivating students' will to learn and developing students' problem-solving abilities. Effective teaching materials have to help the student to identify these problems, get the new resources needed in order to progress, and integrate them into a new problem-solving strategy (Ginestie, 2009). Technological Education should enable pupils to develop their technological ability through opportunities to take part in activities of an extended nature, which take advantage of knowledge, understanding, and skills from many areas of the curriculum (Layton, 1993).

Regarding the practical activity of Technology Education, Parikka et al. (2011) say that

> In Technology Education on one hand machines and equipment (equipment technology) and on the other hand use of tools (manufacturing technology) are studied. Knowledge of the quality of production materials connects these technologies to knowledge of technology. This definition is related to both material and mental aspects. (p. 135)

The importance of the physical environment in Technology Education and its purpose is vividly expressed by Parikka (1998), who notes that in the school learning environments, it is essential that the classrooms expressively present and introduce different everyday technical structures, as it is the understanding of their operation, in particular, that arouses students' interest and inspires various mathematical, scientific, and technological interpretations. Parikka (2003) observes that such practical everyday problems that the students themselves consider relevant provide the most attractive grounds for natural scientific interpretations as well as for joint projects in the field.

In the analysis of a study of five countries in the European Union (Austria, Estonia, Finland, France, and Germany) that concentrated on describing Technology Education for 6 to 12-year-old school children (primary and junior secondary), Rasinen (2011) points out that Technology Education requires better facilities for studying technology—laboratories, workshops, tools and equipment, computers, and various other materials. Writing about the importance of learning environment, Parikka and Rasinen (2009) point out that

> learning environment is the main factor of physical requirements for teaching technology and in many ways it also works as a “quiet” objective

> in behalf of the students. The expediency and spaciousness, salubrity (ventilation, light and heating), equipments (machines, devices, and tools) make up the principal part of the learning environment. Additionally, providing students with materials and tools, computers and computer software and textbooks is dependent on the economic situation of the school. (p. 35)

Baldwin and Barlex (2007) write that in order to successively teach technology and design, an important condition is that the teacher needs to facilitate pupil capability by organising and maintaining an appropriate environment; this means that pupils will have open access to materials, components, tools, and equipment. An authentic learning environment allows students to construct knowledge using real-world contexts and examples (Lee, 2011). Baldwin and Barlex (2007) stress the need of Technology Education for various resources; it is important to have access to a significant consumable expenditure budget and to provide pupils with the materials and components they need to model and make their design ideas.

Alamäki (1999) brings out in his study that in Finland, the respondents indicated that the three most significant obstacles, in order, were: lack of financial resources, insufficient material on how to teach technology education, and lack of other accompanying resources. The learning environment must become more modern and new technologies need to be utilized so that this innovative and future-oriented subject could give students the readiness to follow safety aspects and adopt important safety attitudes (Inki, Lindfors, & Sohlo, 2012). Work safety plays an important role in Technology Education. Various machines, devices, and materials may, if used incorrectly, be dangerous, which is why the goal of basic schools should be to guarantee a healthy and safe environment that supports learning (Kantola, 1997). In planning classes for Technology Education, newer approaches to learning that lean on humanity and social constructivism should be considered, as these stress self-direction, explaining things independently, team work, creativity, innovative approaches, and holism as well as project work that would flexibly integrate subjects.

Method

Aims of the Research

The present article focuses on Technology Education teachers' opinions on the physical learning environment of Technology Education. The study compares and analyses the changes in the physical learning environment of Technology Education.

Participants and Procedures

Two questionnaire surveys (Study I and Study II) were carried out among teachers of Technology Education in Estonian general education schools. In Study I, which was carried out in 2004, 157 teachers participated (women *N* =

8). In Study II, which was conducted in 2011, 109 teachers participated (women $N = 6$). The statistical data processing software SPSS 18.0 was used to process the survey data; descriptive statistics and t-tests were applied.

Measures

The questionnaire is based on a survey used by Rasinen (2000), which was translated into Estonian with certain modifications added. In the present article, I focus on the comparison and analysis of the *physical learning environment* of Technology Education. The physical learning environment block contains 27 questions, which were assessed on the 6-point scale (0 = *cannot answer, I don't know*; 1 = *does not meet the needs*; 2 = *slightly meets the needs*; 3 = *meets the needs partly*; 4 = *meets the needs more or less*; 5 = *meets the needs adequately*). The value "0" was not taken into account when analysing the results.

First, I elicited a general interpretation of the physical learning environment in schoolwork. I asked the teachers of technical subjects to assess the situation of the material technical basis at schools in light of the National Curriculum for Basic Schools, mainly the effective curriculum for Technology Education. As a whole, the questionnaire covered the following topics:

1. *Workrooms.* Including their size, expediency of the location and the arrangement, sanitary situation, etc.
2. *Supply of tools and materials.* The supply of different materials and tools (electro-technical and electronic tools) as well as personal protective equipment, including availability of ergonomic tools in classrooms, etc.
3. *Computers and computer software.* Computers and computer-run workbenches, Internet connection, computer software for planning and designing objects, etc.
4. *Teaching aids.* Including up-to-date textbooks, online teaching materials, video materials, visual aids, etc.
5. *Technical conditions of workrooms.* The correspondence of classrooms to the technical conditions, including electricity supply, ventilation, including the suction system of wood flakes and dust, etc.
6. *Metal processing machines.* Metal processing devices, including thermo-treatment devices, etc.

Results

Table 1 demonstrates the results of the mean of environmental aspects between the years 2004 and 2011. The results revealed that the change toward higher satisfaction was the most apparent in the case of several characteristics. The most significant statistical differences in assessing the physical environment during the two periods were manifested in assessing woodwork machines and resources needed for electro-technical and electronic tools (in both cases $p < 0.001$) as well as resources needed for online teaching materials, computer-run workbenches, and Internet connection (in each $p < 0.001$). An important difference was also apparent in the availability of technical drawing software and size of rooms and workspace ratio (in both cases $p < 0.001$) as well as in the availability of thermo-treating equipments for metals and in using video materials in introducing different types of work (in both cases $p < 0.005$). A considerable difference can also be seen in size of workrooms and in the electricity supply (in both cases $p < 0.01$). There are a number of statements that have a considerable, yet not very strong, statistical difference ($p < 0.05$): availability of various necessary rooms, the sanitary state of the rooms, ventilation, availability of tools, availability of ergonomic tools, digital devices, and availability of computers.

In the case of the following statements, there were no statistically significant differences during the two periods in question: expediency of the location (question 2, $p = .157$), arrangement of rooms (question 3, $p = .100$), availability of personal protective equipment (question 8, $p = .791$) and different materials (question 9, $p = .257$), availability of metalwork machines (question 13, $p = .319$), availability of up-to-date textbooks (question 16, $p = .089$) and visual aids (question 19, $p = .989$), computer software for planning and designing products (question 25, $p = .082$), and means needed for teaching the topics established in the syllabus (question 27, $p = .430$).

Table 1
Comparison of the Satisfaction Scores of Environmental Aspects Between the Years 2004 (Study I) and 2011 (Study II)

Question	*M* (2004)	*M* (2011)	*t*-test *p*
1. Size of workrooms (e.g. the wood processing room too small)	3.09	3.54	t(258) = -2.88, $p < 0.01$
4. Availability of necessary rooms (e.g. painting room and a room for thermo-treating metals)	1.64	1.95	t(253) = -2.22, $p < 0.05$
5. Sanitary state of classrooms (e.g. the state of walls and floors)	3.37	3.77	t(257) = -2.53, $p < 0.05$
6. Ventilation (e.g. aspiration system for removing wood dust and wood chips)	2.00	2.45	t(253) = -2.59, $p < 0.05$
7. Electricity supply (e.g. the availability of an adequate number of sockets)	3.52	3.95	t(291) = -2.91, $p < 0.01$
10. Supply of tools (e.g. pliers, plane, etc.)	2.93	3.24	t(295) = -2.37, $p < 0.05$
11. Availability of ergonomic tools (e.g. work benches with adjustable height, etc.)	2.02	2.39	t(253) = -2.48, $p < 0.05$
12. Wood processing machines (e.g. wood thickness machine etc.)	2.69	3.49	t(257) = -4.91, $p < 0.001$
14. Equipment for thermo-treating metals, (e.g. welding equipments, forge furnace)	1.39	1.66	t(245) = -2.12, $p < 0.005$
15. Electro-technical and electronic tools (e.g. soldering iron, etching bath)	2.71	2.20	t(254) = -3.55, $p < 0.001$
17. Online teaching materials (incl. also CDs)	1.53	2.46	t(241) = -7.53, $p < 0.001$
18. Video materials (e.g. for treating different types of work)	1.53	1.85	t(243) = -2.70, $p < 0.005$
20. Digital devices (e.g. digital camera)	1.44	1.74	t(245) = -2.17, $p < 0.05$
21. Computer-run work benches (e.g. CNC mini milling machines)	1.08	1.72	t(234) = -5.04, $p < 0.001$
22. Computers	1.66	2.03	t(244) = -2.26, $p < 0.05$
23. Internet connection	2.33	3.32	t(255) = -4.56, $p < 0.001$
24. Technical drawing software (e.g. Vertex G4)	1.26	1.82	t(238) = -4.38, $p < 0.001$
26. Size of rooms and work space ratio (e.g. more than 16 students in one lesson)	2.68	3.28	(257) = -3.58, $p < 0.001$

Note: N 2004 = 159; N 2011 = 109. All differences between groups are significant $p < 0.05$.

Comparing teachers' assessments on the physical environment of teaching Technology Education during the two different periods, we can conclude that in 2011, teachers' assessments on most of the statements were considerably more positive. The development is especially evident in a more extensive utilisation of

Internet connection and online learning possibilities. Another important improvement compared to the results of 2004 is the utilisation of woodwork machines, computer-run workbenches (e.g. CNC mini milling machines), and computer-based programs for technical drawing. Based on the questionnaire of 2004, the availability of computer-run workbenches met the schools' needs the least in teachers' opinion because, at the time, such devices were available only in a small number of schools. Also, the availability of technical drawing software did not meet the needs; the same tendency can also be seen in case of software for planning and designing products in 2004. At the same time, assessments on two questions from the questionnaire of 2011 have not been increased compared to the questionnaire of 2004. These were questions about electro-technical and electronic tools and supply of personal protective equipment. These last results show that due to nationwide public procurement concerning this equipment in 2004, the schools have not acquired more of this equipment in the interim. There were no differences in assessing such statements that do not expect larger technological innovations, such as the expediency of the location, the arrangement of rooms, and the availability of textbooks and simpler teaching aids.

Discussion and Conclusions

The objective of the present article was to examine and compare the opinions of teachers in Estonian basic schools on the physical learning environment in light of both the present (since 2011—Technology Education) and the previous (from 2002 to 2011—Craft and Technology Education) curriculum. The present study reveals major changes in the conditions of the physical environment of teaching Technology Education in Estonian basic schools.

The data collected in 2011 reveals significant changes in the conditions of the physical environment of teaching Technology Education. We can say that a statistically significant difference was present in 18 statements out of 27 referring to the physical learning environment. Based on the responses in both phases of the study, we may conclude that most Estonian schools have classrooms for teaching craft and technology education where general teaching can be carried out, which have satisfactory sanitary conditions. Although the improvement has not been striking, it is nevertheless noticeable.

Workroom

From the standpoint of workrooms, it is important to have enough space and work places for students to carry out the learning process. In recent years, many Technology Education workrooms have been renovated and modernized in Estonia. The problem is that in workrooms in older schools, it is not possible to gain more space for Technology Education. It is very important for schools to have workrooms corresponding to the norms that are equipped with the necessary tools and materials (Baldawin & Barlex, 2007; Rasinen, 2011; Parikka & Rasinen, 2009).

Supply of Tools and Materials

Supply of tools and materials varies significantly from school to school. There are schools managing well in the field, and there are those that are considerably lacking. It depends greatly on the financing of the school, and many schools and teachers awaited an increase in material resources. Alamäki (1999) points out the same tendency in his study.

Computers and Computer Software

The most notable changes were seen in the possibilities of using computers and computer software, which is connected with technical drawing software, computer-run work benches, and software for planning and designing products; an equally important improvement was witnessed in using the possibilities offered by the Internet. Although the number of computers in school has increased, it does yet not meet the needs of Technology Education. With the aim of applying information technology in schoolwork, the Tiger Leap Foundation, which helps schools to acquire computer-run workbenches (CNC milling machines) and various computer software (including computer software for technical drawings—e.g., Solid Edge), was founded. For that purpose, the school and the teacher must show initiative and take part in projects, training, and student competitions. The availability of newer study materials (including information technology) in school has considerably improved over the years. Parikka (1998) has stressed the need for introducing different everyday technical structures in Technology Education.

Teaching Aids

The results carried out in two different school years vividly point out that many schools still lack up-to-date teaching aids needed in modern teaching, i.e. video materials and online teaching materials, visual aids, digital devices, and up-to-date textbooks. Over the years we have witnessed considerable improvement in the availability of teaching aids in schools, but nevertheless it is not enough. This is a weak spot in activities supporting the curriculum, namely, there is a lack of teaching aids for Technology Education. Yet, the good news is that the publication *Technology and Creativity* (Soobik, 2011) was issued.

Workrooms and Technical Conditions of Workrooms

Schools maintained by a capable local government generally have better technical conditions in the workrooms used in technology education. Although sanitary repairs are gradually carried out in technology education classes in schools, the need for more frequent repairs is significant. Parikka and Rasinen (2009) point out that the technical conditions of workrooms are an essential aspect of the physical learning environment. Many schools in Estonia do not have adequate ventilation, and the aspiration system for removing wood dust and wood chips can only be found in a small number of schools.

Metal Processing Machines

In recent years there has been a little improvement in using equipment for thermo-treating metals in Technology Education (welding equipment, forage furnace), although in teachers' assessments this aspect has rather been modest. It is possible that teachers lack the necessary means and conditions, or that in their opinion teaching metal processing is not necessary.

The study shows that during the observed period, the physical learning environment of Technology Education has slightly improved in Estonia; a steady progress towards improvement can be seen. Modern study aids are increasingly used in schools, including computer-run workbenches and corresponding programs, etc. However, modernising and developing the physical environment of Technology Education should be an ongoing objective, and means should be found to improve the physical environment of Technology Education in order to teach students using modern technology.

In brief, the following steps can be pointed out to further develop the physical environment of Technology Education:

1. Training courses need to be organised for Technology Education teachers, showing them how to use up-to-date teaching methods and tools in the classroom and how to relate the teaching with actual technological needs, thus making teaching more effective and productive.
2. Teaching materials on Technology Education should be published, and the experience of the specialists in the field on teaching and shaping a better physical environment should be brought out.
3. In planning the learning environment, it should be guaranteed that in addition to rooms and equipment for teaching Technology Education, there would also be possibilities for planning, research, and experimenting, including using a computer and pertinent computer software.
4. Various means, including tools and devices and materials necessary for teaching, should be requested from the financiers of the school.
5. Besides handling tools and processing materials, students should also have knowledge on work safety. The teacher and the school must create a learning environment that enables students to work safely.

The physical environment of Technology Education is equally as important as the content of the subject and the study results, teaching methods, and a professional teacher. Together, these elements form an integrated whole in teaching. Thus, on-going research on the physical environment is vital.

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The Evolving Classroom: A Study of Traditional and Technology-Based Instruction in a STEM Classroom

One need only read the most recent newspaper, periodical or research journal to realize that there is unprecedented change occurring in education. According to Kimmelman (2006), since the seminal report *A Nation at Risk* was published in 1985, the call for education reform has increased dramatically over the last 25 years. During the last ten years, the No Child Left Behind Act of 2001 (NCLB) has ensured that educators at every level focus on accountability, use scientifically-based research, be data driven, and use standardized tests in an effort to improve student learning. Love it or hate it, NCLB has been the catalyst for huge changes in the world of education from kindergarten through 12th grade (K–12). Based on new reform models, some researchers have found that too many students enrolled in K–12 classrooms do not achieve at levels necessary to be globally competitive (National Center for Education Statistics, 2009). Clearly, new policies, expectations, and accountability measures have changed the way teachers teach and students learn.

Any discussion of technology and engineering literacy must start with a clear idea of exactly what technology and engineering literacy means. That, in turn, requires clear definitions of technology. The International Technology Education Association (now the International Technology and Engineering Educators Association) developed the *Standards for Technological Literacy: Content for the Study of Technology* (2000, 2002, & 2007), and the definition of *technology* included in that document was used for purposes of this study:

> Broadly speaking, technology is how people modify the natural world to suit their own purposes. From the Greek word *techne*, meaning art or artifice or craft, technology literally means the act of making or crafting, but more generally it refers to the diverse collection of processes and knowledge that people use to extend human abilities to satisfy human needs and wants. (2007, p. 2)

Some believe that technology is a very effective way of engaging young minds and improving student learning (Carlson, 2005). However, considering the explosion of social media, hand-held technology, and numerous ways for Millennials (the generation born between 1980 and 2000) to get screen time, the fear is that students cannot really focus and multi-task effectively, especially when asked to follow specific instructions. To think creatively, work in teams, and have deep understanding of project-based learning, students must

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Timothy J. Devlin (tim.devlin24@gmail.com) is a former Technology and Engineering Teacher at Lynhurst Middle School in Indianapolis, Indiana, Charles R. Feldhaus (cfeldhau@iupui.edu) is Associate Professor and Co-Director of the STEM Education Research Institute (SERI) at Indiana University Purdue University Indianapolis, and Kristin M. Bentrem (bentrem@iupui.edu) is a Ph.D. student in the Higher Education and Administration program at Indiana University Purdue University Indianapolis

understand that technology is a useful tool but not a replacement for human interaction. There is significantly more information available to be consumed today than in past generations, and Millennials have more ways to consume it than ever before. To say that students do not have the ability to learn, engage, and concentrate greatly underestimates their abilities. Learners have simply grown accustomed to acquiring information and communicating by utilizing technology-based methods (Moore, 2007).

The use of technology has become more prevalent in schools and has been shown to facilitate student learning objectives. According to Gulek and Demirtas (2005), there is substantial evidence that incorporating technology, of any kind, in the classroom as an instructional tool enhances student learning and educational outcomes. Numerous studies (Gulek & Demirtas, 2005; Spires, Lee, Turner, & Johnson, 2008; Edwards, 2007) have found that that using any technology with students who are considered Millennials boosted both concentration and engagement. Students who use technology were (a) spending more time involved in collaborative work, (b) participating in more project-based instruction, (c) producing writing of higher quality and greater length, (d) gaining increased access to information, (e) improving research analysis skills, and (f) spending more time doing homework digitally. Studies have also determined that using technology at the beginning of class sessions helped students stay on task and concentrate (Spires et al., 2008). Additional research is necessary to confirm the findings of researchers who have studied the incorporation of technology in student learning, provide new knowledge about how Millennials perceive the world and their learning experiences, and to provide new pathways for classroom teachers who wish to make a difference in the lives of students by using all tools available to them. This study used the action research model developed by Mills (2010) to better understand the effect that technology has on the delivery of instruction for hands-on, project-based Science, Technology, Engineering, and Mathematics (STEM) assignments to middle school students. This research examined the effect on student ability to follow instructions, think critically, and work collaboratively when the instructions given are given directly through in-person communication or pre-recorded video. Technological advancement in the classroom, engaging the millennial student population, and current teaching methods are discussed.

Literature Review

In 2000, the International Technology Education Association established a formal definition for technological literacy: “Technological literacy is the ability to use, manage, assess, and understand technology” (International Technology Education Association, 2000, p. 7). Many authors (Mentzer & Becker, 2010; Gamire & Pearson, 2006; Pearson & Young, 2002) declare a unifying theme, relative to technological literacy, is that technologically literate people are able to function in our modern technological society. One element that is often contained in the discussion of technological literacy is the concept of technological competence. Autio and Hansen (2002) defined technological competence as an interrelationship between technical abilities in psychomotor, cognitive, and affective areas. Researchers (Layton, 1994; Autio, 2011) have also established three components that are considered dimensions of technological competence: 1) technological knowledge is defined as knowing something about technological concepts, principles, and connections as well as the nature and history of technology; 2) technological skill is defined as tactile and kinesthetic ability as well as practical intelligence (often called psychomotor skills); and 3) technological will is defined as being active and enterprising with regard to technology. It is important for technology education faculty, especially those teaching middle school students, to understand that current students have very different knowledge, skill sets, and understanding of both technological literacy and competence. The concepts of technological knowledge, skill, and will must be considered as STEM educators continue efforts to increase student achievement in a reform-based educational environment.

Using technology to engage students has recently become a topic of research, yet there are vast resources available and the literature has grown significantly in the past five years. There is substantial evidence that incorporating technology, of any kind, in the classroom as an instructional tool enhances student learning and educational outcomes. Gulek and Demirtas (2005) provided students with laptops and observed an increase in collaborative work, better research skills, greater quantity and quality of writing, and more time spent doing homework. Caruso and Kvavik (2005) found that students tend to use technology for convenience for both academic and social activities. Additionally, these researchers found that laptop ownership increased by more than 10% from 2004 to 2005. Students who perceive their instructors to be effective users of technology report greater course engagement, more interest in the subject matter, and better understanding of complex concepts (Caruso & Kvavik, 2005).

Using technology in the classroom has a far greater effect than benefiting just the student population. Gulek and Demirtas (2005) report that teachers that incorporate technology in classrooms generally have a constructivist approach to teaching. They also suggest that the use of technology makes teachers feel more empowered in the classroom and consequently spend less time lecturing because their students are involved in critical-thinking based problem solving activities, active learning, and interactions with fellow students.

Currently, K–12 educators are faced with challenges in both technological literacy and competence. One of the greatest tasks facing educators is how to educate and engage students that live in a world of "ubiquitous information and communications-related digital technologies (e.g. web, hand-held devices, cell phones, and gaming consoles)" (Spires et al., 2008, p. 497). McGlynn (2008) believes that student engagement is the key to academic motivation, persistence, and degree completion. Certainly engaged students are more likely to become technologically literate and competent. Researchers from the discipline of technology education (Koch & Sanders, 2011; Jonassen, 2000; Todd, 1999; Williams, 2000) found that engagement is often maximized if students are exposed to hands-on, project-based curriculum that requires them to solve problems. Students who are provided assignments that give them an opportunity to observe, evaluate, communicate, model, generate ideas, research/investigate, produce, and document success/failure are often self-directed and engaged (Williams, 2000; Koch & Sanders, 2011).

According to Spires et al., (2008) students want their schools to look more like the world around them. They want items in their environment that inspire and motivate them to learn and achieve. In a recent study, when middle school students were asked to describe their ideal educational environments they described schools that had wireless technology, flexible work environments, and work areas that mimic the workplaces of today (Edwards, 2007). Clearly, some researchers believe that educational institutions at all levels, but particularly in middle school, should focus on creating learning environments that emulate the professional environments in which students may one day work.

Millennials and the Art of Educating the Digital Native

Sometimes referred to in the media as "Generation Y," Millennials are the children of the post-WWII baby boomer generation. The Millennial generation has been immersed in technology from birth and thrives on collaboration. This generation imitates previous generations by displaying the light from their cell phones at concerts where once lighters were held high; they don't remember Elton John being in the rock and roll genre, and their parents are older than Kermit the frog (Moore, 2007). Yet, many teacher-training programs are centered on industrial models that existed during the mid-twentieth century. These dated educational methods have created frequent misunderstandings, often prepared newly trained teachers to fail, and, perhaps more importantly, impeded educational improvement, advancement, and change (Woempner, 2010).

> Millennials have already been pegged and defined by academics, trend spotters, and futurists: They are smart but impatient. They expect results immediately. They carry an arsenal of electronic devices—the more portable the better. Raised amid a barrage of information, they are able to juggle a conversation on Instant Messenger, a Web-surfing session, and an iTunes playlist while reading Twelfth Night for homework. Whether or not they are absorbing the fine points of the play is a matter of debate (Carlson, 2005, p. A34).

Carlson (2005) concludes that Millennials expect to be able to choose what, where, when, and how they learn. Educators should be prepared to include blogs, videos, video games, even handheld devices such as iPads and

Blackberries. Although throwing out textbooks and traditional teaching methods might be met with resistance, teachers should understand that "Millennials consume and learn from a wide variety of media, often simultaneously" (Carlson, 2005). McGlynn (2008) believes that the process of reaching these students in order to engage, motivate, and inspire them cannot be ignored. There must be an intersection between how Millennials learn and how educators teach.

> The challenge for the educators and technology developers of the future will be to find a way to ensure that this new learning is highly situated, personal, collaborative and long term; in other words, truly learner-centered learning. (Naismith, Lonsdale, Vavoula, & Sharples, 2004, p. 36)

Wisniewski (2010) observes two major paradigms in today's schools: behaviorist and constructivist. Advocates for the behaviorist paradigm believe that the purpose of educators is to transfer knowledge to another in the form of direct instruction and memorization and then to judge effectiveness with a traditional assessment. Efficiency is key, and the transfer of knowledge is time sensitive and normally done through lectures. In contrast, advocates of the constructivist paradigm believe in a very different approach. Constructivists believe that knowledge is built on top of existing knowledge. They also believe in demonstrating real world connections to increase engagement and authenticity. The core belief of this form of education is that students play an active role in constructing new knowledge. The learning is student-centered and the teacher takes on the role of facilitator. Shaw (2009) contrasts these methods in recent research, and the differences between the two methods can be seen in Table 1 (continued next page).

Table 1
20th Century vs. 21st Century Education (Shaw, 2009)

20th Century Classroom	21st Century Classroom
Time-based	Outcome-based
Focus on memorization of discrete facts	Focus on what students know and can do
Lessons focus on the lower levels of Bloom's taxonomy—knowledge, comprehension, and application	Lessons emphasize upper levels of Bloom's taxonomy—synthesis, analysis, and evaluation
Textbook-driven	Research-driven
Passive learning	Active learning
Learners work in isolation	Learners work collaboratively with classmates and others around the world

Teacher-centered: teacher is center of attention and provider of information	Student-centered: teacher is facilitator/coach
Fragmented curriculum	Integrated and interdisciplinary curriculum
Teacher is judge. No one else sees student work	Self, peer, and authentic assessments
Curriculum/School is irrelevant and meaningless to the students	Curriculum is connected to students' interests, experiences, talents, and the real world.
Print is the primary vehicle of learning and assessment	Performances, projects, and multiple forms of media are used for learning and assessment
Literacy is the 3 R's—reading, writing, and math	Multiple literacies of the 21st century—aligned to living and working in a globalized new millennium.

Most schools are involved in a paradigm shift as they move away from traditional methods and more toward a constructivist approach (Wisniewski, 2010). Studies show that today's college graduates have spent less than 5,000 hours of their lives reading text, while they have spent over 10,000 hours playing video games and 20,000 hours watching television (Prensky, 2001). This generation has been characterized as *digital natives* (Prensky, 2001). A digital native is defined as a person that has grown up immersed in technology and often has the characteristics seen in Table 2. The educators that are trying to engage students are considered *digital immigrants*, and often they are learning digital technology as if it was a second language (Prensky, 2001).

Table 2
Digital Native Characteristics (Prensky, 2001)

Grew up with technology	Function best when networked
Parallel process and multi-task	Thrive on instant gratification and frequent rewards
Prefer graphics before text	
Prefer random access	Expect adults to consult and include them

Generational misunderstandings regarding technology use can hamper communication. However, if the digital immigrant generation would utilize technology in the same way as the Millennials, it would break down communication barriers and ultimately benefit the educational process. Educators need to modernize their methods and ignore their generational preferences if they truly want to engage every student (Woempner, 2007).

Methodology

According to Mills (2010), action research is any systematic inquiry conducted by teacher researchers, principals, school counselors or other stakeholders in the teaching/learning environment to gather information about how their schools operate, how they teach and how well their students learn. In short, action research is done *by* teachers *for* themselves. Mills (2010) recommends appropriate methods to collect data in action research, and his five steps of inquiry were used to conduct this action research investigation: (1) identification of problem, (2) collection and organization of data, (3) interpretation of data, (4) action based on data, and (5) reflection.

The problem was identified as lack of focus and inability of middle school students to follow instructions at the beginning of class during courses taught at a high-needs urban middle school of over 1,100 students. A concurrent triangulation mixed method action research design was then developed based on questions for mixed methods study created by Creswell (2009).

> In a concurrent triangulation approach, the researcher collects both qualitative and quantitative data concurrently and then compares databases to determine if there is convergence, differences, or some combination [of the two]. Some authors refer to this as *confirmation*, *disconfirmation cross-validation*, or *corroboration* (Green, Caracelli, & Graham, 1989; Morgan, 1998; p. 213)

This traditional mixed methods model is advantageous to action researchers because it "can result in well-validated and substantiated findings" (Creswell, 2009, p. 213–214).

Materials and Procedure

The key elements of this study included a hands-on, problem-solving, STEM activity, written instructions either read by a classroom teacher or delivered through video, an observation checklist, a two-question survey, and seven interview questions asked of a focus group. Table 3 provides a synopsis of the STEM activity and the directions provided to students. The survey questions (Appendix A) asked students to specify how instructions where given to them and then to rate their ability to understand the instructions on a scale from 1–10. The interview questions (Appendix B) asked the students to describe the instructions they were given and to describe their perceptions of the of the instructional delivery method.

Table 3
STEM Activity: Instructions Delivered to Students

1. Work in groups of three.
    - If an uneven amount of students, then form two groups of two
2. Work together to use the paper and the tape placed on their desks to design a structure that could hold a regular textbook 10” above the table.
    - The lowest part of the textbook and distance to the table had to be at least 10”
    - Hold as many books as possible
    - Do not ask any questions about the assignment
3. All groups of 2 or 3 received the following materials:
    - Four sheets of 8.5” by 11” sheets of regular computer paper
    - Six inches of masking tape
    - A pair of scissors
    - A ruler

To ensure the instructions were as similar as possible, a bulleted list of criteria that needed to be covered was created (Appendix C). The video instructions were filmed with a Canon Rebel T2i video recorder. The video was edited in Adobe Premiere and included some additional materials such as music and text that emphasized the instructions. The video was uploaded to YouTube and can be found at http://www.youtube.com/watch?v=nk4v6xEYN0s.

On the first day of class, a group of students who were new to both the course and teacher came into the classroom and a PowerPoint was displayed with instructions to prepare a nametag and await instructions (Appendix D). Once the nametags were prepared, the class was greeted and attendance was taken. Each class was told that in a few moments, there would be instructions given to the entire class and that follow-up questions would not be permitted. Three of six classes were shown the video, and the other three were given verbal instructions and shown a PowerPoint presentation.

After the instructions were given, the instructor stayed in front of the class until groups were formed. Then, each group was given the materials as outlined in Table 3. Researchers utilized an observation sheet to chart student behaviors (Appendix E). Behaviors observed included the number of questions asked, number of non-three-person groups formed, and if instructions were followed. Each group was given 30 minutes to complete the challenge.

At the conclusion of the challenge, each participant was given a brief survey (Appendix A). One class from each instructional delivery method was invited to remain for a focus-group interview where pizza was served. Twenty-two students were interviewed and served as a focus group for the various delivery methods. The focus group interactions and responses were recorded with an iPhone and were later transcribed.

Participants

Participants were self-selected by enrolling in the class in which this research took place. No students who elected to take these classes were excluded. Class sizes were predetermined and unaltered for this study, and participants were not excluded on the basis of ethnicity, gender, or learning ability. It was assumed that participants fairly represent the entire student body because they were obtained from the preexisting class rosters and the classes were open to the entire middle school population. Internal procedures for classroom action research as outlined by the policy manual of the school corporation were followed, and the entire experiment was reviewed and approved by the university institutional review board

Six classes were utilized for this study. Three classes, consisting of fifty students, received video instruction and three classes, consisting of thirty-seven students, received in-person instruction (Table 4).

Table 4
Participant Numbers by Class and Instruction Method Utilized

Class	Students	Instruction Medium
1	18	Video
2	14	Verbal
3	24	Video
4	8	Verbal
5	8	Video
6	15	Verbal

Results

Three data collection methods were used to collect both qualitative and quantitative data for this study. A survey was provided to all students who participated in the exercise, a selected focus group of participants were interviewed, and an observation checklist was used in an effort to triangulate data. Survey data and results from the observation checklist were designed to provide quantitative data, and focus group interviews were designed to provide participant perceptions of the experience and qualitative data. The results of each method of data collection are included, and various appendices are provided so readers have access to instrumentation.

Survey and Focus Group Interview Results and Comparisons

Following the activity, all participants were given a survey (Appendix A). They were asked to rate, on a scale from 1–10, their ability to follow the instructions that were given. Of the students that received video instruction, 86.58% stated that they could follow the instructions provided. Of students that received in-person instruction, 85.07% stated that they could follow the instructions.

Findings reveal differences in the ability of participants to follow instruction based on the instruction-delivery method. The percentage of participant-groups that completed the activity differed by 1.51%. However, during the activity, it was observed that many students in both classes were watching other groups and then troubleshooting their own design to resemble the groups that were successful.

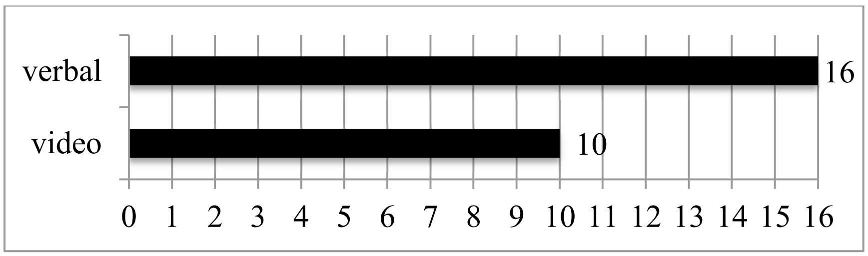

Figure 1. Average number of questions asked per class.

When observing the number of questions each group tried to ask the teacher, a significant difference between groups emerged, as seen in Figure 1. The participants that were given the video instructions asked an average of ten questions, while the classes that were given in-person instructions asked an average of sixteen. Additionally, students in the video-instruction group asked if they were allowed to make statements as opposed to asking questions. It was observed that students who received video-based instruction were more likely to correct each other when they started to ask a question than those students that received in-person instruction.

There was also a difference in the number of participants that either asked their own groups if they could get more materials, tried to take more materials, or asked the instructor for more materials, as seen in Figure 2. An average of four groups from the participants given in-person instructions tried to acquire more materials, while only an average of two groups who received video-based instruction asked for more materials. One group that was given verbal instructions tried to organize the class into one large group so they could share all of their materials. The participants that received video-based instruction were less likely to request or try to acquire more materials for their project.

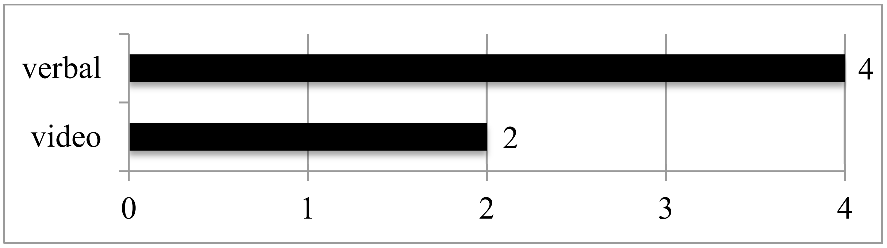

Figure 2. Amount of requests for different materials.

As part of the instructions given, group size was also observed and noted as to number of participants in each group (Figure 3). The participants shown video-based instructions were more likely to follow the instructions, while the participants shown the in-person instructions had an average of two student-groups that did not follow instructions. Because it was the first day of classes, some students arrived after the instructions were given.

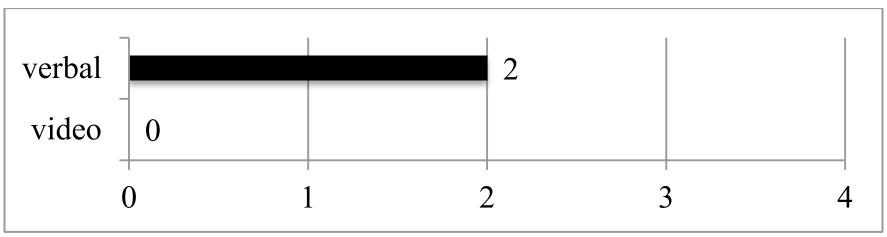

Figure 3. Groups formed not containing two or three members.

The classes that were shown the video instructions were able to explain to the newcomers that they had to find a group that contained only two students. It was observed that if a group with four participants formed, those students were more likely to disengage earlier than other groups. Observations found that participants given video-based instruction were more likely to remain engaged when compared to participants given in-person instruction. It was also noted that students given video-based instruction were more likely to accurately follow the instructions than groups that were given in-person instruction.

Focus Group Interview Results

Question #1. Participants were asked various questions (Appendix B), and a variety of sub-questions, during the focus-group interview. Student responses revealed a difference in the ability to reflect on the instructions depending on how instructions were delivered. Participants were asked to describe the instructions they were given. Students who received in-person instructions offered a brief recollection of the instructions that were given. They were not able to reflect on or offer any comments to describe the instructions. The only response other than reciting the instructions came from one student that said, "The instructions were easy." Some responses included erroneous information such as "We were told we couldn't ask questions" and "We were given four pieces of paper and three pieces of tape and we had to hold a book six inches off the table."

In contrast, when asked to describe the instructions, students who received video-based instruction offered a greater amount of reflection. Students perceived the video-based instructions to be easier, more likely to be understood, and easier to recall. Participants observed that they were more likely to pay attention because it was a video and not a teacher. One student commented on attention span stating that participants had to concentrate on the video, rather than being able to talk to each other. Most students described a sort of novelty to the video instructions, which resulted in their own observation of higher engagement. One participant said, "Our instructions were given over video, which I thought was pretty cool… you have to push yourself to pay attention, it pushes you to remember." Additionally, some participants felt that "kids will focus on (video-based instructions) more than when a teacher gives them." Another student simply stated, "It is harder to concentrate when a teacher is talking."

Question #2. Next, participants were asked to describe what they liked most and least about the instructions. Participants given the in-person instruction were less responsive to this question. Student comments include having an increased understanding of the instructions "because it was from [the teacher] and not the computers" and "that [delivery of the instruction] wasn't going too fast or too slow." Other students felt that the instructions were straightforward and questions did not need to be asked. The less reflective nature of their answers could be a result of the students being given instructions in the same manner that they are used to receiving them, and students shown video-based instructions had something to compare to the status quo instruction delivery methods.

Participant responses reinforced the novelty of using video and, correspondingly, increased student engagement. One student said that the "first thing I liked was that it was on a video, I had never seen that before," and another felt that "it was a new way to understand things and it made me understand them a lot more." Other comments from students included general observations such as “the video was more fun” and “cool.” Students felt that video-based instruction “[got] to what you need to do quicker so you [could] do better than what the teacher said.” Participants also felt that teachers were apt to provide extraneous information saying, “I liked how the video was to the point… the extra stuff confuses me” and “[the video is] easier because when a teacher talks it takes *way* too long.” Contrary to these comments, another student thought that “Teachers leave out parts of the instructions [and that watching a] video makes it more simple.”

Participant comments reinforced their trust in technology communication and were further emphasized because the instructions that were given in-person were the same as video-based instruction. Additionally, students perceived the video as more informational than verbal instructions even though the teacher provided additional examples in the in-person instruction. One student was able to succinctly sum up this general feeling by saying, “In a video you are shown instead of told.”

When asked what they liked least, both groups of students sighted frustration with not being able to ask questions. Although this was the limit of complaints for the video-based instruction group, the in-person instruction group was more prolific and varied in their responses, oftentimes contradicting each other. One student responded with, “I would prefer the teacher [in-person] over a YouTube video, unless I was in a big class then I would want videos.” One participant suggests that “it would have been easier watching a video because you could have answered more questions” and “video can show better examples,” while another suggests the opposite, “it’s easier to understand the person than to watch the movie, even if you play it back over and over.”

Question #3. Some respondents recognized that a teacher could use video-based methods to complement instruction effectiveness and aid in student understanding. Students displayed an appreciation for in-person instruction by explaining that a teacher can modify their instructions, but a video can only repeat the pre-recorded instructions. Participants cited potential barriers to effective video instruction included audio issues, lack of understanding, and not being shown how to complete the project. Students who received video-based instruction communicated their understanding that technology is not always reliable and a teacher can always supply more instruction.

One student, extended beyond their comfort zone, stated, “(I) had to ask my group more questions, and I don’t do that much.” Another student spoke to group collaboration, “Afterwards, I couldn’t figure out what to do, I couldn’t ask questions so I had to stick to my group.” Although provided as “negative” evidence of the video-based instruction, these statements are quite positive in providing both social and cognitive problem solving development. “The video helped us know who we were working with, [it] helped us know the other people,” as said by one student. Many listed not being able to ask questions as a barrier. However, students shown the video-based instructions seemed to consistently say that the instructions forced them to work more collaboratively and think more critically.

Question #4. Participants were then asked how they overcame the barriers they described. Both groups expressed that they were more likely to look to their groups in order to have their questions answered. However, their main reasoning for this was not because of the instructions they were given but as a result of them not being able to ask any questions. In support of this finding, one group responded, “If no one on the team knew, we would keep thinking [until we] figure it out.”

Question #5. Finally, both groups were asked to provide any comments regarding the delivered instruction. Some general negative responses received from the in-person instructions group included “[in-person] instructions stay in my head easier, while videos I can just zone out” and “sometimes videos are a little more confusing.” Positive comments from this group included “I liked how you were very straight to the point; you told it how it is” and “It was fun being forced to figure it out.” Another student thought that a “teacher would have more time to help” than just watching a video.

The student responses indicated that in-person instruction could be more confusing if the teacher elaborated. Students also thought that videos could be fun and interesting in some situations. Some participants were in favor of a multifaceted approach that utilized both in-person and video-based instruction stating that “It would be cool to have both” and “I think it would help to have both video and a teacher.”

Students who preferred the video-instruction felt that “it was a lot better than sitting down and watching a teacher talk” and that “watching a video made me more interested to get [my work] done.” One participant who felt more comfortable with the video stated, “I would definitely watch a video before asking a teacher [a question].” One student interested in skill development suggested, “It made me work more with a group than I normally do and that is something I need to do more.” The researchers found that some students perceived that the instruction was better simply because it was presented using video; “I think they were better instructions because they were on a video.”

Students all agreed that the class could not take place without the teacher, and they expressed their appreciation for a teacher’s ability to incorporate videos into instruction. Student perceptions seemed to agree with Caruso and Kvavik’s (2005) findings that teachers who possess the ability to incorporate technology affect higher student engagement, more student interest, and greater student understanding.

An analysis of the student responses from transcribed focus group sessions revealed numerous common themes. Student focus group common themes are detailed in Table 5.

Table 5
Findings/Common Themes

Student Focus Group Common Themes	Video-Based	In-Person
Critical thinking demonstrated through responses.	X	
More responsive answers.	X	
Perceived instructions novelty of technology.	X	
Perceived instructions were informative.	X	
Perceived instruction aided understanding.	X	
Perceived instructions were reliable.		X
Perceived instructions helped critical thinking	X	
Perceived instructions helped collaborative work	X	
Perceived instructor could help facilitate understanding	X	X
Perceived extraneous information could be confusing		X

Conclusions, Recommendations, and Lessons Learned

The students that answered the questionnaire perceived no difference in understanding the instructions. However, participant perception and action did not equate because when comparing the video groups to the in-person groups, there was a significant difference in the amount of correct groups formed and the amount of questions that were asked. Students all perceived that they understood the instructions given, regardless of method of delivery, but their actions (forming incorrect groups, asking questions, etc.) indicate otherwise. According to the results of the observation checklist, students who received instructions via video seemed more engaged in the activity and were able to stay engaged without asking questions. Also, they completed the project to specification in the time allotted. Students who received instructions for the exact same assignment from the teacher were less likely to exhibit those behaviors. Additional research should be completed with larger sample sizes to determine if delivery of instructions for complex, hands-on, project-based STEM activities result in increased ability to follow instructions, think critically, maintain focus, and complete tasks to specification. Additionally, variables such as learning style, gender, race, geographic location, and age should be taken into account in these studies.

The students that saw the video were more reflective on the instructions they were given. Many students that were given verbal instructions were very slow to recall their feelings and perceptions of the event. The students given the video instructions seemed more excited about the project and declared that the video encouraged them to work in their groups more and inspired them to critically think. Based on the findings it is apparent that the application of video-based to in-person instruction can be beneficial to student engagement and learning. However, more observations need to be done on a grander scale to verify these findings. Research using other social media methods such as Facebook, Twitter, and Skype should be developed to determine if these media sources enhance or detract from the ability of middle school students to follow instructions and perform tasks. Additionally, studies should be performed to determine other factors that might influence middle grade student perceptions of the most efficient and beneficial ways to receive instructions. Various issues attributed to Millenials such as rapid, free-choice, random access to data, information, and resources should also be examined by learning science researchers.

To expand upon this study, various and different types of video instruction should be prepared and delivered so that educators can assess benefits on student learning. In this study, both qualitative and quantitative data analysis revealed that participants who received initial instructions via video displayed a higher level of engagement, but it must be conclusively determined if that can be attributed to the utilization of technology and, if so, what types of technology. Future work could include investigating the instructor's willingness to answer questions and the resulting effect on student critical thinking skills. It was found that students were less likely to ask questions when given video-instruction instead of instructions given in person. Students who received video-based instruction were more likely to adhere to instructions and utilize critical thinking skills more often. These outcomes support findings that students in classes where teachers utilize more information technology will report more engagement, more interest in the subject matter, and a better understanding of complex subjects. But the real question is why?

Although this research indicates that video instruction better engaged students, once uniformly implemented, the novelty of this instruction delivery method may diminish. Given that technology and its accessibility continue to advance and change, educators will be challenged not only to keep pace but also to ensure that they stay abreast of the latest technological developments and use them as learning tools to reach Millenials. This research suggests that educators must keep technological pace with students and diversify their teaching methods in order to keep students engaged. Additional studies could focus on the adaptability of teachers who educate utilizing behaviorist methodology and those who tend to use constructivist methods.

This small study came from a realization by the authors that students were not paying attention and engaging in class assignments. This often caused discipline problems and a sense of chaos in this urban, middle school classroom. The author came to realize that the first minutes of class are crucial to student engagement and set the tone for the rest of the class period. As a result, this mixed methods action research study was designed to not only inform practice for other technology and engineering faculty who teach Millenials but also to inform the author. Clearly, the findings of the study are not generalizable;

however, in keeping with the traditions of action research, the author did learn lessons that will impact action and reflection. Those lessons include:

1. The use of technology, in this case YouTube, may indeed play a role in engaging middle school students during the first, crucial minutes of an engineering design assignment.
2. Students perceived that the use of YouTube technology to deliver assignment instructions was beneficial and helped them better understand the requirements of the assignment and focus on what was required for a successful outcome.
3. This author will continue to use various social media to engage students in a variety of ways.

Hopefully, more action research will be conducted on the issues revealed in this study and a body of knowledge will be constructed. If high quality teaching in an urban middle school setting is to flourish, teachers must try all methods possible to engage students. This study shows promising results to that end.

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Appendix A

Post-activity survey questions.
Thank you for completing this activity. Please answer the following questions as accurately as possible.

1. **Please circle whether you were given instructions by video or from your teacher.**

   Video or Teacher

2. **Rate from 1 to 10 your ability to understand the directions that were given to you.**

   1 2 3 4 5 6 7 8 9 10

Appendix B

Interview Questions after the Activity

1. Describe the instructions you were given during class.
2. What did you like best and least about how your instructions were delivered?
3. What were the benefits and barriers of the way your instructions delivered?
4. How did you overcome the barriers you describe above?
5. What other comments do you have regarding how the instructions were delivered?

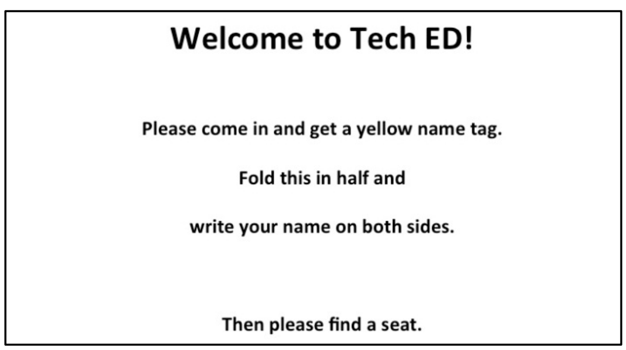
Appendix C

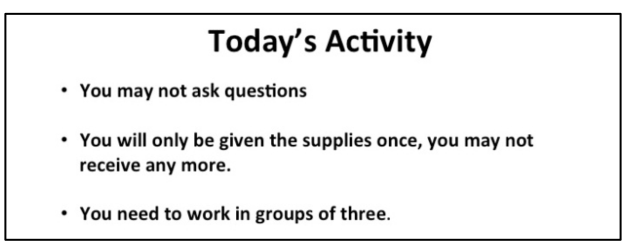
List of Criteria for Instructions.

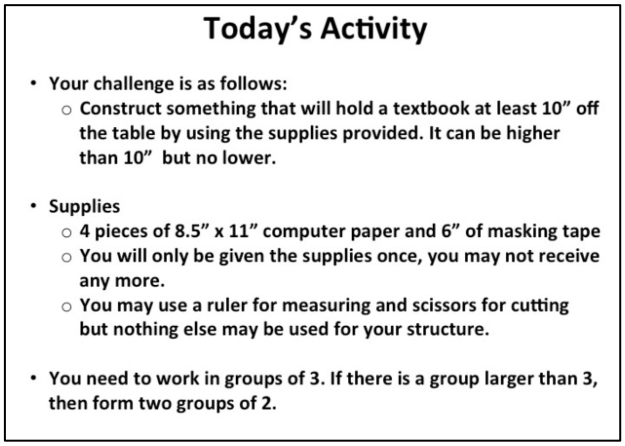
- No questions will be asked
- Only the following supplies:
  - 4 sheets of 8.5" by 11" computer paper
  - 6" of masking tape
- No additional supplies will be given
- Ruler and scissor may be used to measure and cut but nothing else.
- Must work in groups of 3, if there are more than form 2 groups of 2
- You will have thirty minutes to complete activity.
- If you hold one your challenge is to hold as many as possible.

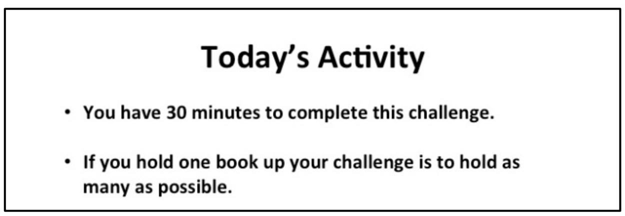
Appendix D

PowerPoint Presentation for Verbal Instruction









Appendix E

Observation Checklist
How many students tried formed groups of numbers other than three?

How many students tried to use other materials besides the provided?

How many questions were asked after the presentation?

How many groups completed the task in the amount of time provided?

General observations:

Developing Effective STEM Professional Development Programs

To help the United States stay globally competitive in terms of innovation and invention, the teaching of science, technology, engineering, and mathematics (STEM) has become a priority in P–12 education today. As the need for students to become stronger in STEM grows, so does the need for well-qualified STEM teachers who understand what is needed to develop relevant and high-quality STEM programs. Professional development (PD) can offer opportunities for those involved in the teaching of STEM to learn how to effectively integrate various instructional approaches, including *engineering design* into their teaching and learning environments.

Engineering Design is a very popular method used by engineers to solve problems. ABET (2011) has set a variety of criteria for accrediting engineering programs and in their discussion on criteria related to developing engineering curriculum, they note that engineering programs must devote adequate attention and time to engineering design.

> Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs. (p. 4)

Engineering design is also a very important concept taught in technology and engineering education as evident by the emphasis it is given in the *Standards for Technological Literacy: Content for the Study Technology* (International Technology Education Association, 2007). For example, standards 8 through 13 in the *Standards for Technological Literacy* cover many of the concepts and principles associated with design and using the design process to solve problems. Further evidence of the importance of learning about engineering design can be seen in the draft version of the soon to be released *Next Generation Science Standards* (National Research Council, 2012) that states a commitment to

> fully integrating engineering and technology into the structure of science education by raising engineering design to the same level as scientific inquiry in classroom instruction when teaching science disciplines at all levels, and by according core ideas of engineering and technology the same status as core ideas in the other major science disciplines. (p. 1)

Teaching about engineering design to those in STEM can be accomplished through PD.

Zanj K. Avery (zavery@calstatela.edu) is an adjunct faculty member at California State University, Los Angeles and a STEM Educational Consultant. Edward M. Reeve (ed.reeve@usu.edu) is a Professor at Utah State University.

Today in America, there is a call to increase student's interest in STEM that places an emphasis on inquiry based learning approaches and engineering design. In his 2012 State of the Union address, President Barack Obama stressed the importance of STEM education by stating, "Think about the America within our reach: A country that leads the world in educating its people. An America that attracts a new generation of high-tech manufacturing and high-paying jobs." Important in the training of the next generation of STEM education teachers is to identify ways of integrating engineering design into the science, math, and technology education areas. One method of integrating the concepts of engineering design into science, math, and technology education is through PD.

A need exists to examine factors that can contribute to successful PD in the STEM areas, especially as it concerns integrating engineering design into core academic subject areas. To help advance these efforts, a qualitative study was conducted to examine the effects of PD on infusing engineering design and problem solving into STEM curricula areas.

Professional Development in STEM Education

Professional development is important to STEM education, especially in the areas of technology and engineering. If engineering is to be recognized as an integral part of science, technology, and math education, stakeholders, organizations and/or people directly involved have to share the burden of responsibility for these ideas to become reality (Bybee & Loucks-Horsely, 2000). Many feel that this can be achieved through PD, especially PD that promotes a deep understanding of the subject matter along with the best pedagogical practices. A deep understanding of the subject matter helps teachers to facilitate student learning (Shulman, 1986).

Brophy , Klein, Portsmore, & Rogers (2007) point out that there is a need to identify methods for helping P–12 teachers develop the necessary skills and capabilities to connect students with engineering design in the classroom. Moreover, if teachers are to inspire or encourage students to pursue a career in engineering or any of the STEM fields, they need to be aware of what engineers are and what they do; this can also be achieved through PD.

In developing PD in the area of STEM, Custer, Daugherty, Zeng, Westrick & Merrill (2007) note that there are many facets related to the development and delivery of effective PD programs. These facets include: (a) research plans, (b) development of a philosophical focus, (c) identification of standards-based curriculum materials, (d) collaboration amongst STEM disciplines, (e) formulation of effective PD models, (f) research specific to pedagogical content knowledge, and (g) general justification and promotion of engineering and technology education as a recognized part of K–12 education. The focus of this study is on (e): the formulation of effective PD models

Central to this study were the STEM PD efforts conducted by the National Center for Engineering and Technology Education (NCETE). In 2005 and 2006, NCETE sponsored a series of PD activities that steered a number of research efforts at various universities including: California State University, Los Angeles (CSULA); University of Wisconsin-Stout; Brigham Young University; and the University of North Carolina A&T. The purpose of these activities were related to the identification of core engineering concepts, the production of logic models of effective PD, and the development of successive engineering design challenges (Asunda, 2007; Asunda & Hill, 2007; Custer, Daugherty, Zeng, Westrick, & Merrill (2007).; Tufenkjian & Lipton, 2007).

This study focused on the PD activities held at CSULA during the spring and summer of 2006. The purpose of the study was to investigate the overall effects that the NCETE STEM PD had on teaching practices. The results of the study were used to produce recommendations that could be used by PD developers to enhance the quality of STEM PD programs.

Background of the Study

Two years had elapsed between the 2006 NCETE-sponsored PD workshops at CSULA and the time that this study was conducted. During the interim, teachers who participated in these workshops had ample time to modify their instructional materials to include what they learned into their classroom and laboratory projects. Based on what was presented in the NCETE/CSULA PD workshops, this qualitative case study concentrated on the following research questions:

1. What effects did the PD have on teachers' classroom practices in terms of the PD content that they incorporated?
2. What types of challenges did teachers face as they implemented what they learned from the PD workshops?
3. What benefits did the PD provide in terms of teaching as well as the teachers' perceptions of benefits to student learning?

The NCETE professional workshops were broken up into two phases, consisting of a spring and a summer workshop. The spring workshop phase consisted of six Saturday meetings from 9:00 a.m. to 5:00 p.m. This schedule was intended to reduce any interference with the teachers' respective teaching schedules. The workshops focused on the following actions: (a) Setting the scene, (b) creating a cohort, (c) describing the engineering profession, (d) diagnosing abilities, (e) providing foundational instruction, and (f) introducing the engineering design method (E. Lipton, personal communication, September 15, 2008). Particularly, the spring phase was dedicated to providing each of the teachers with the necessary math and science content knowledge needed to succeed in engineering problem solving and to introduce the engineering design process. In addition, the spring phase included STEM applications and activities, presentations given by guest speakers from the CSULA engineering department (i.e., electric and civil engineering instructors), pedagogy (i.e., project-based learning involving active, collaborative learning, open-ended problem solving, critical thinking, and tangible outcomes), and outside experiences (i.e., tour of CSULA engineering facilities and a field trip to Cal Tech's seismic research facility).

The summer workshop phase consisted of five 8-hour-long sessions that were given within a one-week period. The focus of the summer workshop was to: (a) model how an engineering design challenge was performed in the class, (b) provide teachers practice with how to solve design problems, (c) teach the teachers how to infuse engineering design into high school programs, (d) study curriculum models, and (e) learn how to assess engineering design. Specifically, the summer phase concentrated on giving the participants instruction and practice in the application of an exemplar teaching model related to the design of earthquake resistant buildings.

Research Design

This qualitative case study organized three sources of data concerning NCETE PD workshops at CSULA: teacher interviews, teacher documents, and classroom observations. The data in this study were collected from four in-service high school teachers who participated in the 2006 NCETE PD workshops. The three sources of data were examined to ascertain patterns and themes. It is important to note that the teachers who participated in this study were between 2 to 3 years removed from the workshops. This gave each teacher ample time to reflect on what they learned during the workshops and to implement what they learned into their teaching practices. After receiving teacher consent, a one-hour in-person recorded interview was conducted with each teacher at their school.

The interview questions were based on the previously stated research questions, and an interview guide was used to direct the researcher during the interviews. The interview guide consisted of seven open-ended questions and a series of probing questions that were used to extract more in-depth responses. In addition to the teacher interviews, triangulation of the data was achieved through the collection of teacher documentations and classroom observations.

Teacher Documents

In this study, teachers were interviewed and teacher documents, such as course outlines, lesson plans, and design briefs, were collected and reviewed to see how teachers had revised their classroom and laboratory practices. According to Stake (1995), this method assists in the search for the convergence of information and is directly associated with data situations in the development of a case study. Examining teacher documents provided further insight into the effect that the NCETE/CSULA PD had on the infusion of STEM education into their high school curricula. Evaluation of teacher documents was facilitated through the use of a seven-step engineering design process model that contains a checklist, which included each step of the engineering design process as presented to the 2006 teacher workshops participants. The researcher evaluated the teacher documents to see how closely they aligned with each of the seven-steps.

Classroom Observations

Classroom observations were conducted during the winter of 2009 to help triangulate the findings of this study. These observations, collected as field notes, were used to corroborate statements made during each teacher interview, especially as it concerned how each teacher was using what they learned in the workshops. Overall, the classroom observations helped to provide a better understanding of student behaviors as it concerned STEM learning.

NCETE/CSULA PD Workshop Documents

An additional source of information used to inform this study was the NCETE/CSULA 2006 summer workshop documents. These documents provided guidelines for infusing engineering design into their instructional materials and were helpful in analyzing and linking teacher statements to what actually transpired during the workshop.

Data Analysis

The analysis of data was performed using a qualitative case study approach. Case studies are particularly useful in depicting a holistic portrayal of individual experiences and results regarding a program (Patton, 2002). There is no standard format that exists for analyzing and reporting case study research (Creswell, 1998). Each qualitative case study is unique; therefore, each analysis of a study is unique (Patton, 2002). The analysis of data was customized and revised to specifically address the research question (Huberman & Miles, 1994).

Data were organized in a way that illustrated how each teacher was applying what they learned in the workshops in their classrooms to develop a case study narrative. The narrative is a readable story that integrates and summarizes key information around the focus of the case study. The narrative was structured so that the results could be understood and interpreted by readers unfamiliar with the project (Creswell, 1998).

After reviewing each of the teacher's individual responses, visual images or tables of the data were created to identify themes that were common to each teacher's individual case (Spradley, 1980). This was done to package the information collected through the interviews. To do this, each teacher's case was cross-compared to isolate themes or patterns from their individual responses. From these individual responses, relevant themes emerged which were used to generate overall thematic findings. For example, individual teacher cases were compared to ascertain commonalities within each of the teachers' experiences and how each of the teachers implemented what they learned in the workshops. These commonalities highlighted the strengths and weaknesses of the

NCETE/CSULA PD workshops. Aspects of this study included: (a) demographic information about the teachers (collected prior to the interviews), (b) ways in which the teachers integrated engineering-related PD content and pedagogy into their instructional materials, (c) major differences in instructional methods noticed about the teachers after the PD workshops, (d) indicators of successes and failures, and (e) key quotes from the teachers concerning how the NCETE PD workshops affected their instructional practices.

The analysis of qualitative case study data adheres to a rather logical sequence of steps that employ an iterative model. In this study, an iterative model proposed by Huberman and Miles (1994) was used. This model conformed to a meticulous data analysis spiral and consisted of the following general procedures:

1. Data Reduction—finding a focus, managing data, reading and annotating
2. Data Display—categorizing data, linking data, connecting categories
3. Conclusion Drawing and Verification—corroborating evidence, producing an account.

Data reduction. The first step in the qualitative case study analysis process is data management (Huberman & Miles, 1994). This process helps to facilitate the organization of data into file folders, index cards, and computer files. Following the organization and conversion of audio-recordings into text, the transcripts were read thoroughly while the audio recordings were methodically reviewed several times. By doing this, an overall understanding of the material was developed (Tesch, 1990).

Data display. Each participant's interview was analyzed for a detailed understanding of the effect that NCETE-sponsored PD had on teaching methods. Subsequently, each teacher interview was scrutinized to expand the researcher's understanding of each teacher's perception. Finally, a cross-comparative analysis of all of the teachers' experiences was performed after each individual interview was scrutinized to determine what the common experiences were with regards to infusing engineering content into their classroom and laboratory instruction (Yin, 1989).

During the analysis of the data, the narratives of the teachers' statements were written as separate accounts to avoid losing the individual value of each of the teacher's statements. These individual statements were then compared with other teacher statements for connections or similarities of data which fostered the development of themes based on the effect that the NCETE-sponsored PD had on their instructional practices.

According to Lincoln and Guba (1985), interpretation involves making sense of the data or what can be called the lessons learned. These interpretations may stem from a social science construct or idea or from an amalgamation of personal insights when compared or contrasted with a social construct or idea. At this point in the analysis, the researcher had the capacity to form a more pragmatic view of what transpired in regards to the effect that the NCETE-sponsored PD had on infusing engineering design into STEM classroom and laboratory projects.

Description of PD Workshop and Teacher Backgrounds

The goal of the 2006 NCETE PD activities at CSULA was to facilitate the teaching STEM concepts and principles, especially as it concerned engineering design, to high school students. Specifically, NCETE learning outcomes that were associated with the CSULA PD goals were as follows: (a) develop teachers' instructional decision making to focus on the analytical nature of design and problem solving needed to deliver technological and engineering concepts, (b) facilitate teacher initiated change in program design, curricular choices, programmatic and student assessment, and other areas that will impact learning related to technology and engineering, (c) develop teachers' capabilities as learners so that they assume leadership for their PD activities, including recruiting and mentoring their colleagues, (d) create a pool of highly skilled cooperating teachers who would accept pre-service technology teachers into their classrooms and mentor the next generation of technology/engineering teachers to effectively teach students of diverse backgrounds, (e) develop engineering analysis and design skills in technology teachers, including strengthening their mathematics and science knowledge and skills, and (f) develop curriculum integration and collaboration skills in practicing technology teachers so that they could effectively collaborate with science and mathematics teachers (D. Maurizio, personal communication, September 16, 2008).

Population

Although there were originally seven teacher participants in the 2006 workshops, one retired (early), and another dropped out due to health reasons. So the final pool consisted of five teachers. Out of these five teachers, four teachers from the 2006 cohort agreed to participate in the study. The teachers who participated in this study included 1 female and 3 males. They will be referred to as Teachers A (female), B, C, and D.

The teachers that participated in the CSULA/NCETE PD workshops during the spring and summer of 2006 were diverse with respect to their educational backgrounds, experiential knowledge, and teaching needs. Two of these teachers (A and B) entered the workshops with no previous experience teaching STEM-related content. They both taught core academic subjects (physics and chemistry). The other two teachers (C and D) entered the workshops with previous experience teaching STEM-related content. The following paragraphs present a brief background of the teachers who participated in the study.

Teacher A. Teacher A earned a bachelor's degree in biology. Although she was credentialed to teach biology, she had been teaching physical science and chemistry classes for 6 years at the time of the study. She had experience teaching gifted and non-gifted students and also mentioned that she mentored other teachers on how to teach science. Prior to her participation in the PD workshops, Teacher A had no engineering experience and no prior involvement with STEM education.

Teacher B. Teacher B, a chemistry teacher, started his teaching career as a long-term substitute teacher who worked with troubled youth for 3 years. He spent 2 years teaching English in Costa Rica. At the time of the study, it was his third year teaching high school chemistry. Like Teacher A, he also entered the PD workshops with no engineering experience and no prior involvement with STEM education.

Teacher C. Teacher C, who had a degree in industrial education, was also credentialed in physics and math. At the time of the study, he had been teaching STEM-related courses (e.g., electronics, mechanical design) for more than 20 years. After attaining his degree in industrial education, he decided to take engineering courses to help accentuate his understanding of engineering design and problem solving. He seemed to have the most experience teaching STEM-related content.

Teacher D. Prior to his participation in the NCETE workshops, Teacher D worked as an electrical engineer who made a career change to become a high school teacher. Because he had industrial experience as an engineer, it seemed fitting that he taught Career and Technical Education (CTE) classes such as robotics, digital electronics, computer programming, and physics. Teacher D received a B.S. in electrical engineering and also had a credential in physics with an authorization in math.

Findings and Discussion

During the analysis of the data collected in this study, three major themes common to all the research questions emerged: (a) incorporation of PD content, (b) challenges with incorporating PD content, and (c) benefits of incorporating PD content. These themes were helpful in answering the aforementioned research questions and are discussed in the following sections.

Findings Related to Theme #1: Incorporation of PD Content

Research question one examined the effects that PD had on teachers' classroom practices in terms of the PD content that they incorporated into their teaching practices. Bear in mind that the NCETE PD workshops focused on STEM educational theories and issues concerning how to teach students problem-solving and analytical skills, and how to apply this knowledge within a real-world context. In this study it was found that each of the teachers mentioned that the workshops provided an educational model that demonstrated how teachers could better integrate these theories into their classroom practices through contextualized problem-solving activities and real-world applications. These findings revealed that the NCETE PD workshops appeared to have a positive effect on helping the teachers to connect STEM educational theories with teaching practices and, in turn, provide their students with more enriching learning experiences.

Findings Related to Theme #2: Challenges with Implementing PD Content

Research question two examined the types of challenges that teachers faced as they implemented what they learned from the PD workshops. In this study, it was found that challenges with implementing the NCETE PD content were as follows: (a) evaluating group projects (e.g., all teachers felt that they needed to learn how to better assess group projects), (b) standards-based pressures (e.g., Teachers A, B, and C mentioned how there was not enough time to do STEM projects for every lesson rather they needed activities or projects that could be completed in one to two class sessions), (c) availability of authentic engineering design challenges (e.g., Teachers A and B noted that very few so-called engineering design challenges required predictive analysis prior to building something), and (d) developing STEM lessons (e.g., due to the lack of STEM projects that required students to use predictive analysis, more training on how teachers could develop their own was desired, especially as it concerned Teachers A and B).

Findings Related to Theme # 3: Benefits of Incorporating PD content

Research question three examined the benefits of incorporating STEM PD content into high school curricula. This thematic finding was viewed in light of both teacher and student benefits. Based on each of the teachers' perceptions, they felt that the STEM PD benefitted their classroom practices because it: (a) facilitated teaching, (b) increased student motivation for STEM learning, (c) kept students engaged with the subject matter, (d) increased student appreciation for science and math, (e) improved student thinking and problem-solving skills, and (f) improved student learning.

The findings of this study revealed key areas/issues that are pertinent to developing effective STEM PD programs. The following paragraphs present a brief discussion of these area/issues and, in turn, were used to extract recommendations for developers of STEM PD programs.

Supportive Teacher Learning Environment

The importance of having a supportive environment cannot be emphasized enough when conducting a STEM PD program. The professionalism and support provided by the workshop staff and coordinators stood out in the minds of the teacher participants. They mentioned the importance of : 1) serving good and healthy meals, 2) providing teacher stipends, 3) having a willingness to listen to teacher ideas and recommendations for PD improvement, 4) having good PD presentational and organizational skills, 5) showing respect for what teachers do and teach, and 6) providing the necessary support for teachers to sustain what they learn through STEM PD. The above factors left a positive impression plus imparted a feeling of acceptance, worth, and appreciation for the teachers participating in PD.

STEM Teaching Model

Each of the teachers in this study noted that the engineering design challenge, which was used as a STEM teaching model, had a lasting effect on their teaching practices. This STEM teaching model helped to delineate how to teach students engineering problem-solving and analytical skills, as well as, how to apply this knowledge within a real-world context (as noted in Theme #1). For example, Teacher C stated that “the teaching method is one thing that the workshops solidified.” He went on to explain,

> …what the workshops actually did for me was to give me an engineering model where you define the problem, I present the physics, and the chemistry, then the mathematical tools, then we make an actual model.

Furthermore, Teacher D explained that when he took the workshops, it was during his first year of teaching and the workshops helped him to look at his previous position as an engineer and view it within a teaching context “so it was a wonderful model to have for a reference point.”

A STEM Philosophy

For each of the teachers in this study, it was important that the STEM PD workshops were based on a strong STEM educational philosophy. For Teacher D, one of the strongest impacts of the STEM PD was, in his words, “the philosophy of the workshops…the attempt to integrate [science, technology, engineering, and math] at the same time and the fact that it is possible to do it and that you will get better results.” It was also noted that without a strong rationale (or justification) for doing engineering projects in the classroom, teachers and schools may be less likely to buy into STEM PD efforts.

Evaluation of Group Projects

Those who develop STEM PD should consider all aspects of developing and implementing STEM projects including student group work. Each of the teachers in this study mentioned the challenges that go along with evaluating students working in group settings. For example, Teacher A discussed how she sometimes found it difficult to discern which students were contributing and which students were not. She explained, “when you’re doing group work, it’s really hard to know whose really working and who is not…” Teacher D also discussed similar challenges with evaluating student projects and group work. Despite these challenges, all of the teachers noted the importance of working in a team environment. They felt that it was an important life skill that transcends the STEM disciplines.

Standards-Based Pressures

As previously noted (See Theme #2), standardized testing pressures affected the amount of time teachers could dedicate to STEM learning, especially as it involved the delivery of engineering design challenges. Although the teachers in this study expressed a desire to employ more of what they learned in the PD workshop, these standards-based pressures impeded their ability to infuse more engineering design/STEM projects into their lesson plans. For example, Teacher B stated that, “I can’t have an open-ended challenge that takes two weeks…It just won’t work.”

To address the above concerns with standards-based pressures, the teachers in this study acknowledged that the PD workshops inspired them to develop their own standards-based STEM lessons so that they could satisfy their individual teaching needs. Teacher B stated, “I need little mini lessons…little mini challenges that the kids can do.” To add, Teacher D stated, “it would actually be a distraction in the physics classroom to do a large number of projects.” Overall, the teachers that taught core academic subjects, such as physics and chemistry (Teachers A, B, and D), expressed that they did not have much time to spend on one particular project. Instead, they expressed a need for smaller, less time-intensive projects that could support the educational materials needed to prepare their students for standardized testing.

Recommendations

To address the above issues and challenges, the following six recommendations are presented, as a sort of a framework, for those involved in the development and delivery of STEM PD programs:

Recommendation #1: Provide a Supportive PD Environment

It is recommended that STEM PD developers provide an environment that is: 1) organized, 2) supportive of the personal and professional needs of teachers, and 3) values the input of teachers. This way, teachers can gain a greater sense of ownership and, in turn, be more inclined to buy into and sustain STEM PD efforts.

Recommendation #2: Provide an Exemplar Engineering Design Challenge

To lay a good foundation for infusing STEM education into traditional classrooms, especially as it concerns engineering design and problem-solving, it is recommended that STEM PD developers provide an exemplar engineering design challenge (EDC) for teachers to use as a reference model. The EDC should demonstrate how to do engineering design and problem-solving within and outside of the classroom. Moreover, it should include aspects of the engineering design process, i.e., keys steps used in the problem solving processes that engineers use to solve real-world problems. The EDC should be available for teachers, if they so choose, to integrate into their instructional materials. For teachers who have never done engineering design with their students, this will help reduce uncertainties about how to effectively perform projects that involve STEM learning.

Recommendation #3: Provide Training on Managing Group Projects and Evaluating Student Contributions

It is recommended that STEM PD developers continue to provide insight and training to teachers concerning how to evaluate group projects, especially as it deals with assessing individual student participation. Group work is time consuming and may involve covering less topics but research reveals that group work helps students to develop an enhanced ability to solve problems and indicate a better grasp of the material (Cooper, 1990). Plus, it is reflective of how people work together in a real-world setting.

Recommendation #4: Developers of STEM PD Should Consider Standards-Based Pressures That Impact STEM Learning

It is recommended that designers of STEM PD continue to consider ways to help teachers remediate the standards-based pressures they face when they engage in teaching STEM-related content. The following recommendations may proffer suggestions for this overarching issue:

Recommendation #5: STEM PD Should Train Teachers How to Develop Their Own Standards-Based, Engineering Design Challenges

It is recommended that designers of STEM PD provide training to teachers on how to develop their own standards-based, STEM lessons and engineering design challenges. Furthermore, this training should provide teachers with strategies on how to develop more short term STEM and engineering design challenges. As a corollary, Wilson (2007) states that PD needs to employ teacher knowledge as an integral component of the PD design as well as bridge the gap between research and practice.

Recommendation #6: STEM PD Should Train Teachers How to Integrate STEM Concepts into Their Instructional Materials

Designers of STEM PD should include training on how teachers can integrate appropriate levels of science, technology, engineering, and math into their curriculum content. To do this, it is recommended that PD developers review appropriate STEM content standards (e.g., those that will be included in the *Next Generation Science Standards*) that provide grade appropriate learning experiences.

STEM PD should not only be viewed as a means of making learning more relevant for students but should also be considered as a means of bringing greater relevance to teaching.

Conclusion

With recent pushes in the U.S. to infuse engineering design into science, math, and technology education, the preparation of teachers with the ability to develop relevant and high quality STEM programs becomes vital to these efforts. Given that teachers have a direct influence over student learning, it is important to invest the necessary resources to help teachers provide the best quality STEM education for their students. Achievement of these goals can be realized through quality PD programs.

Because of its interdisciplinary nature, the delivery of STEM education, especially as it concerns engineering design, requires teachers to cover a wide range of academic concepts and principles while making meaningful connections between various academic subject areas. In developing STEM PD, it is important to note that teachers will be unique with respect to their educational environments, backgrounds, and experiential knowledge. This means that a one-size-fits-all model will not be conducive to preparing a diverse group of teachers with the necessary knowledge, skills, and abilities to deliver STEM education to their students. This is especially true as it concerns core academic subjects such as math and science which have added pressures due to standardized testing requirements. Moreover, teachers will be expected to provide their students with a good balance between rigor and relevance while using engineering design as an organizer for core academic subjects such as science and math.

As learned through this study, the development of effective STEM PD programs requires a synthesis of approaches that incorporate the best educational practices found in: a) general PD literature, b) science and math PD research, as well as, c) engineering and technology PD research. By doing this, as a nation, we can better provide existing and future teachers with a profound understanding of the subject matter they convey. In turn, these teachers can help cultivate the minds of the next generation of creative thinkers that will carry the world forward in terms of scientific and technological innovation.

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A Comparative Analysis of Point-of-View Modeling for Industrial and Technology Education Courses

Enrollment in technology education at the college level has been declining (Isbell & Lovedahl, 1989; Volk, 1997; Daugherty, 1998; Hill, 1999; Ndahi & Ritz, 2003; Moye, 2009). It is essential for technology teacher educators to investigate ways to increase the enrollment in their programs, or the profession may fail to provide technology teachers in the future (Ndahi & Ritz, 2003). A solution that several institutions with technology education programs have adopted is the offering of the program via distance learning. Distance learning "allows participants to collapse time and space" (Cole, 2000, p. ix). According to Flowers (2003) technology education programs "with a history of hands-on learning at the undergraduate level" have been slow to implement distance learning techniques and strategies (p. 64). Therefore, it is important to explore the extent to which distance-learning technologies such as video modeling can be used by industrial and technical teacher education faculty. The intention of this study is to add to the body of knowledge on effective video modeling procedures and, in particular, the point of view used when recording instructional videos.

Purpose

The purpose of this research was to identify which point of view—reportorial, subjective, or objective—better promotes content understanding and learning for hands-on activities in a technology education and industrial technology context.

The hypotheses that guided this study were:

H_0: There is a significant difference among the reportorial, subjective, and objective instructional points of view for industrial and technology education courses.

H_A: There is not a significant difference among the reportorial, subjective, and objective instructional points of view for industrial and technology education courses.

Review of Literature

Video modeling involves making a video of someone performing a specific task or application (Cannella-Malone et al., 2006). It can be described as a technique used to model a target skill by another individual whose actions and language are videotaped. A person watching the videotape of the targeted skill is expected to imitate behavior of the model as it is observed in the video

Petros J. Katsioloudis (pjkatsiol@odu.edu) is an Associate Professor in the Department of STEM Education at Old Dominion University; Todd D. Fantz (tfantz@regis.edu) is an Assistant Professor in the Department of STEM Education at Regis University; Millie Jones (mjones@odu.edu) is a Graduate Student in the Department of STEM Education at Old Dominion University.

(D'Ateno, Mangiapanello, & Taylor, 2003). The video is then shown in its entirety to the individual at the beginning of each teaching session. After viewing the entire video, the individual is given the opportunity to perform the task in its entirety. Video modeling and prompting have been successfully used to teach a variety of functional skills such as withdrawing money from an ATM (Alberto, Cihak, & Gama, 2005), purchasing items in a store (Alcantara, 1994; Haring, Kennedy, Adams, & Pitts-Conway, 1987), daily life skills such as brushing teeth (Charlop-Christy, Le, & Freeman, 2000), setting the table (Cannella-Malone et al., 2006), cooking (Shipley-Benamou, Lutzker, & Tauman, 2002), and vocational skills (Mechling & Ortega-Hurndon, 2007). According to Ayres and Paas (2007), there is growing extant literature on the use of video instruction for functional skills and trying to integrate technology (e.g., Mechling, 2004; Mechling & Cronin, 2006; Mechling & Gast, 2003; Norman, Collins, & Schuster, 2001).

Instructional video has been categorized based on the different points of views used while filming the video. McCoy and Hermansen (2007) defined point-of-view modeling as "the visual image that would be seen if the participant was engaged in the behavior including, images of hands demonstrating a specific skill, for example" (p. 185). Point-of-view video models are visual images that allow the participant to see a skill as if they were engaged in the behavior, including images of hands demonstrating a specific skill (McCoy & Hermansen, 2007). The three main points of view used for instructional videos are: (a) subjective, (b) reportorial, and (c) objective (Burrows and Wood, 1986). For the purposes of our study, we explain each of these points of view below.

The *subjective* point of view is often recommended as the dominant perspective. In the subjective point of view the students sees everything from the *instructor's eyes* point of view (see figure 1). "It has the potential to enhance a feeling of viewer participation, in contrast to the objective 'eavesdropper' perspective" (Willis, 1994, p. 179). To capture the subjective point of view, a camera would need to be mounted on top of the instructor's head, facing the work being performed.

The *reportorial* point of view was often referred to as the view that comes from a non-biased source, in this case, from *next to the instructor's eyes*.. For this specific point of view the student sees everything as if he/she were standing to the side of the instructor (see figure 2). A camera needs to be positioned to the left or right of the instructor, facing the students, to represent the reportorial view for the instruction.

The *objective* point of view is one in which the students receive *face-to-face* instruction (see figure 3). "most closely emulates face-to-face conversation and enables the instructor to maintain eye contact, through the lens of the camera, with the distant learner" (Willis, 1994, p. 179). In addition, Mechling (2005) stated that "the video camera moves as if it were the viewer and shows what is supposed to be seen through his/her eyes" (p. 29).

Figure 1. Subjective Point of View

Figure 2. Reportorial Point of View

Figure 3. Objective Point of View

Stahmer, Ingersoll, and Carter (2003) suggested that video modeling may succeed when other methods have failed. Hammond, Whatley, Ayres, and Gast (2010) noted that video gives the learner an opportunity to view the content repeatedly at any time, provides the instructor with easy editing ability to customize footage for the learner, and provides an authentic environment that mirrors real world experiences. Video modeling can also be an effective intervention for reducing problem behaviors, increasing play actions, and teaching functional living skills. Researchers have used video modeling to teach individuals such skills as purchasing (Alcantara, 1994; Haring et al., 1987), conversation (Charlop & Milstein, 1989; Sherer et al., 2001), perspective taking (Charlop-Christy & Daneshvar, 2003; LeBlanc et al., 2003), spelling (Kinney, Vedora, & Stromer, 2003), and daily living (Shipley-Benamou, Lutzker, & Taubman, 2002).

While most of the video instruction literature relates to research in special education (specifically autism), its applicability to groups of college students in the field of industrial and technology education seems like a perfect fit. Bowie (1986) found that film is very effective in teaching observational skills and in training learners on important details. In addition, Bowie (1986) indicated that using this method for problem-solving activities, skills of inquiry, and discovery may be an effective vehicle for delivering instruction. Mechling and Ortega-Hurndon (1997) reported the value of video technology in simulating "settings, events, and scenarios…that will generalize from the school to community environments" (p. 25). In addition, Moore and Anderson (2010) noted that point-of-view video modeling may be effective in the "[reduction] of problem behaviors, increasing play actions, and teaching functional living skills" (p. 208).

Some other advantages and disadvantages in video modeling may include (but are not limited to):

Advantages

- Easily duplicated, reusable, and portable
- Convenience of use by the trainee
- Can be used anywhere/anytime (distance learning, etc…)

Disadvantages

- Trainee can control the process of learning in more complex material where the instructor should be present
- Trainee may fast-forward through critical parts of film
- May not be as effective for students who have high aptitudes in math and linguistics (Bowie, 1986)

Video modeling can also be an effective intervention for reducing problem behaviors, increasing play actions, and teaching functional living skills. Schreibman, Whalen, and Stahmer (2000) conducted several experiments using point-of-view modeling in which problematic behaviors were reduced and maintained during post treatment and during 1-month follow-up visits. A study performed by Hine and Wolery (2006), revealed that during play action, actions were increased based on the video modeling condition presented. Children were shown a video where a pair of hands properly manipulated toys in a bin, and once the children viewed this video they were instructed to play with the toys based on what had been shown in the video. During baseline children performed two types of actions; however, the video modeling implementation showed the number of actions doubled to four. Follow up with video modeling revealed the number of actions to remain high from four to six actions.

According to Moore and Anderson (2010), point-of-view video modeling research is a relatively novel approach with little published research. Prior to Moore and Anderson's study, only six studies on the subject had been published: Alberto, Cihak, and Gama (2001); Hine and Wolery (2006); Norman, Collins, and Schuster (2001); Schreibman, Whalen, and Stahmer (2000); Shipley-Benamou, Lutzker, & Taubman (2002); and Sigafoos, O'Reilly, and Cannella (2005). Scheibman et al. (2000) described their model as *priming*, while Sigafoos et al. (2005) described their model as *prompting* (Moore & Anderson, 2010).

However, there is much to be learned about the elements of the model and of the processes and contexts in which it is presented, which leads to differential effectiveness of the point-of-view modeling process. According to Moore and Anderson (2010), very little published research is available on this variant of video modeling. First studied in 2000, point-of-view video modeling was recorded using the subjective perspective. Since 2000, four additional studies have been conducted using video footage from the perspective of the viewer. In this footage, only hands were visible to the viewer (McCoy & Hermansen, 2007). "One of the theoretical foundations of video instruction relates to observational learning" (Bandura, 1969, 1977; as cited in Hammond, Whatley, Ayres, & Gast, 2010, p. 525). Specifically, Bandura noted that student engagement in observational learning (or learning skills) is related directly to their observation of others performing those skills (Bandura, 1969, 1977; as cited in Hammond et al. , 2010).

Methodology

A quasi-experimental study was selected as a means to perform the instructional point-of-view study during the spring semester of 2012. The study was conducted in a materials process course, STEM221, offered at Old Dominion University as a part of the STEM program. The population of the study was the course participants, and since STEM221 contains several hands-on projects where instruction through demonstration is common the researchers felt that the group was appropriate. The study's goal was to identify which point of view—reportorial, subjective, or objective—better promotes content understanding and learning for hands-on activities in a technology education and industrial technology context.

This materials process course introduced the students to basic content and skills needed to process common materials and produce functional products using woods, metals, plastics, and composite materials. This course also included laboratory safety, use of hand tools, and operation of machinery. Course content was reiterated to students through laboratory discovery experiences in materials testing and construction of multi-material projects. Pedagogy and learning outcomes were based on the creation and demonstration of physical products.

Three instructional films demonstrating facing, turning, and drilling on a lathe were created by the researchers and validated by instructional technology faculty at the college. To prevent bias all films were of the same length and used the same narrative piece of activity explanation. The first film was created using a subjective point of view using an overhead camera. The students in this case were able to receive instruction through the instructor's eyes. The second film was created using an objective point of view. The students in this case were able to receive face-to-face instruction. The third film was created using the reportorial point of view. The students in this case were able to receive instruction from a point of view next to the instructor's eyes, more specifically, to the right side of the instructor, as if they were standing next to him.

All three films share the same narrative instruction, which were filmed at the same time, with the only difference being the point of view. All groups watched the same films. After viewing the films, the student participants were divided in three groups ($n1$=14, $n2$=15, and $n3$= 14 with an overall population of N = 43 and completed a written content quiz related to the demonstration. The groups were then sent into three different rooms according to the three different instructional views to demonstrate the three lathe applications, turning, facing and drilling, on the lathe. Each group only watched the assigned point-of-view modeling. During the demonstration on the lathe, the instructor, with the help of a teaching assistant, completed a direct observation instrument to identify activity completeness. Prior to the experiment, the instrument was validated using graduate students during lab activities, and a positive correlation was observed. The instrument measured time that it took to complete activity, comfort level, and overall completion results. Using a 1–5 Likert scale, the researchers were able to document the results. Using both the written quiz and direct observation instrument, analysis of the data began.

Data Analysis

The first method of data collection involved direct observation of the participants as they physically replicated the instruction. The instructor and teaching assistant scored the participants on a scale of 1–5 on their ability to complete the activity. The instrument had three categories: (a) time to complete activity, (b) comfort level (hesitation in between different steps of the process), and (c) overall completion of the activity. As shown in Table 1, the group that received instruction via subjective means ($n = 14$) had a mean observation score of 4.07. The groups that received instruction via objective ($n = 15$) and reportorial ($n = 14$) views had higher observation scores of 5.86 and 5.14 respectively. A one-way ANOVA was run to compare the mean scores for significant differences among the three groups. The result of the ANOVA test, as shown in table 2, was significant, $F(2, 40) = 14.54$, $p < 0.01$. The data was dissected further through the use of a post hoc Tukey's honestly significant difference (HSD) test. As it can be seen in table 3, the post hoc analysis shows a statistically significant difference between the subjective and objective points of view ($p < 0.001$, $d = 2.08$) and the subjective and reportorial points of view ($p = 0.008$, $d = 1.54$), with the subjective point of view being significantly lower in both cases.

After viewing the instructional videos, a quiz was given to the participants. The quiz was given to each of the three groups of Reportorial, Subjective, and Objective, based on the instructional exposure of the participants. As shown in table 4, the groups that received the instruction via subjective views ($n = 14$) and objective views ($n = 15$) had similar quiz scores of 30.57 and 28.66 respectively. The group that received instruction via reportorial views ($n = 14$) achieved a higher mean score of 36.21. A one-way ANOVA was run to compare the mean scores for significant differences among the three groups. The result of the ANOVA test, as shown in table 5, was not significant. However, it should be noted that the group who received instruction with reportorial views was the only group to score well with both hands-on demonstration and written comprehension.

Table 1
Direct Observation Descriptive Results

Quiz	*N*	*Mean*	*SD*	*Std. Error*	*95% Confidence Interval for Mean*	
					Lower Bound	*Upper Bound*
Subjective	14	4.071	.2672	.0714	3.917	4.225
Objective	15	5.866	1.1872	.3065	5.209	6.524
Reportorial	14	5.142	.9492	.2537	4.594	5.690
Total	43	5.046	1.1537	.1759	4.691	5.401

Table 2
Direct Observation ANOVA Results

Quiz	*SS*	*df*	*MS*	*F*	*p*
Between Groups	23.531	2	11.765	14.536	< 0.001*
Within Groups	32.376	40	.809		
Total	55.907	42			

* Denotes statistical significance

Table 3
Direct Observation Tukey HSD Results

Views (1 vs. 2)	Mean Diff. (1-2)	Std. Error	*p*
Subjective vs. Objective	-1.80	0.334	< 0.001*
Subjective vs. Reportorial	-1.07	0.340	0.008*
Objective vs. Reportorial	0.724	0.334	0.090

* Denotes statistical significance

Table 4
Quiz Descriptive Results

Quiz	*N*	*Mean*	*SD*	*Std. Error*	*95% Confidence Interval for Mean*	
					Lower Bound	*Upper Bound*
Subjective	14	30.571	12.023	3.213	23.629	37.513
Objective	15	28.666	8.121	2.096	24.169	33.164
Reportorial	14	36.214	8.945	2.390	31.049	41.379
Total	43	31.744	10.099	1.540	28.635	34.852

Table 5
Quiz ANOVA Results

Quiz	*SS*	*df*	*MS*	*F*	*p*
Between Groups	441.067	2	220.533	2.295	.114
Within Groups	3843.119	40	96.078		
Total	4284.186	42			

* Denotes statistical significance

Discussion

This study was done to determine any differences among points of view with video modeling instruction and to identify if any provided better instruction for students in industrial and technology education courses. In particular, the study compared the objective, subjective, and reportorial points of view. It was found that the objective view (face to face) and the reportorial view (shot next to the instructor's head) both provided statistically significant higher scores than the subjective view (shot from where the students are standing) when the students demonstrated what they learned. While not statistically significant, the students who received instruction via the reportorial view outperformed their peers who received instruction from the other two views on a written quiz. This could indicate that students were better able to comprehend instruction given from the eyes of the instructor or reportorial view, over the objective and subjective views. If this is the case, a major question arises: Why is the subjective point of view used most often in instructional videos?

It should be noted that the majority of instructional videos created in the past and today use the objective point of view as the primary one, regardless of the academic subject and content area. Using instructional videos to teach industrial technology and technology education hands-on tasks has great potential. We have the ability to share instructional resources, such as pre-recorded videos, and provide instruction to students at a distance. However, it appears that more research is needed on the camera view used to shoot those videos. This small exploratory study provided results contrary to the commonly used method of placing a camera facing the instructor to represent the view of a student in front of the activity. Instead, a view from the instructor's eyes by placing the camera on the head of the instructor while shooting seems to give the students a better understanding of the task being taught.

The researchers suggest that the current of point-of-view database on video instructional modeling be strengthened by repeating the study with additional sections of the course. The researchers also plan to review courses outside of the materials process course that contain additional academic majors, engineering technology in particular, to determine if this course is representative of the programs in general. In addition, the researchers are interested in further exploring the optimal point of view. Further research is needed to determine if cultural differences have an effect. An assumption could be that different eastern European cultures favor a different point of view over another.

While conducting the literature review to better focus this research, it was determined that there was a lack of research undertaken on cognitive technical distance learning. By understanding the optimal point of view for distance learning in technology education and industrial technology, distance instruction can be enhanced through the use of recorded or live video feeds.

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Measuring Teacher Effectiveness When Comparing Alternatively and Traditionally Licensed High School Technology Education Teachers in North Carolina

According to No Child Left Behind (NCLB), the definition of a highly qualified teacher includes three components: obtaining a bachelor's degree; having full licensure as defined by the state; and demonstrating competency, as defined by the state, in each subject taught (U.S. Department of Education, 2004). However, NCLB does not specifically include career and technical education, of which technology education is a part. In North Carolina, all fields of career and technical education, except trade and industrial, follow NCLB's requirements for achieving the highly qualified teacher status (North Carolina Association of Teachers, 2005; North Carolina Department of Public Instruction, 2009). Due to the difficulty of filling all teaching positions with highly qualified teachers, an alternative licensure program was established to allow individuals without an education degree from a university-based teacher preparation program to transfer their skills from the workplace into the classroom (Hoepfl, 2001).

Although originally developed to quickly fill openings in an emergency situation, alternative licensure is now being used more readily for filling teaching positions. This has caused some concern about the effectiveness of the alternatively licensed teachers. Some educators feel that an alternatively licensed teacher does not have the necessary understanding of pedagogical theories and practices they would obtain when completing a traditional education program (Darling-Hammond, Holtzman, Gatlin, & Heilig, 2005). Because of this lack of pedagogical knowledge, this teacher would have difficulty fully accommodating students' educational needs and would not be able to develop and deliver effective lesson plans. This in turn would result in lower student achievement. Darling-Hammond et al. found the other side of the debate is, through practical industry work experiences, alternatively licensed teachers have gained knowledge about the course content that is more in-depth than the knowledge gained in the traditional education program. From working in the corporate field, a teacher would have learned more authentic applications of the content knowledge and could therefore be able to provide the students a more relevant experience in the classroom than would a traditionally licensed teacher.

When measuring student achievement, current research shows mixed data on the effectiveness of alternatively licensed teachers compared to that of traditionally licensed teachers (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Bradshaw & Hawk, 1996; Hawley, 1992). There has been little research,

Bradley Bowen (bradley.bowen@ndsu.edu) is an Assistant Professor in K-12 STEM and Engineering Education at North Dakota State University.

particularly in North Carolina, concerning these comparisons in the field of technology education (Foster, 1996; Haynie, 1998; Hoepfl, 1997, 2001; Merril, 2004; Pavlova, 2005). However, from 1986–1996, there was a 12% increase in the number of alternatively licensed teachers in North Carolina (Bradshaw & Hawk, 1996). With the increase in alternatively licensed teachers, there is a greater need for research in this area.

This quasi-experiment was designed to determine if there was a significant difference in teacher effectiveness when comparing alternatively licensed and traditionally licensed high school technology education teachers in North Carolina. The methodology was designed to use both a quantitative and qualitative approach to utilize triangulation. If the outcomes are similar, there is evidence the results of the study are valid (Bryman, 2006; Creswell, 2003; Jick, 1979).

The research questions were as follows:

1. Are there significant differences in achievement, as measured by percent proficiency on the end of year test, of students taught by alternatively licensed technology education teachers versus those taught by traditionally licensed technology education teachers in North Carolina?
2. Are there significant differences in the pedagogical management practices, as measured by time on task, of alternatively licensed technology education teachers versus traditionally licensed technology education teachers in North Carolina?
3. Are there significant differences in the preparation, performance, and professional development needs, as measured by the principal's perception, of alternatively licensed technology education teachers versus traditionally licensed technology education teachers in North Carolina?

By comparing test results, the students' time on task, and qualitative data, a conclusion can be drawn as to whether or not there are any differences in alternatively licensed technology education teachers and traditionally licensed technology education teachers in North Carolina.

Methodology

Research Question 1

For the first research question, the sample included all of the technology education teachers in North Carolina that were eligible based on the requirements of the study. The sample consisted of two groups, the alternatively licensed technology education teachers and the traditionally licensed teachers. A one-way ANOVA quantitative analysis used the percent of students proficient on the end of year exam as the dependent variable and the teacher's licensure type as the independent variable. End of year test scores have historically been used to measure teacher effectiveness (Clotfelter, Ladd, & Vigdor, 2006;

D'Agostino & Powers, 2009; Sawyer, 2007). These tests are easily graded and relate to student achievement in a particular course. However, there is much debate about using standardized test scores as a definitive measure of teacher effectiveness. Therefore, end of year test scores were used as only one component of this research study. The test results came from the North Carolina standardized VoCATS exam from the Career and Technical education department for the 2009–2010 school year and included five courses within the NC technology education curriculum: Fundamentals of Technology, Communication Systems, Manufacturing Systems, Structural Systems, and Transportation Systems. This information is available to the public but must be formally requested through the North Carolina Department of Public Instruction (NCDPI) research department. The researcher chose these five courses because these are the only courses within the NC technology education curriculum that can be taught with a basic technology education license and have a standardized end of course exam. All other technology education courses were not included in the analysis because they require an add-on certification and cannot be taught by a regularly licensed teacher or do not have an end of course exam. Having an add-on certification means that teacher attended a workshop in which specific content knowledge was gained. The purpose of only using courses that do not require additional certifications is to limit, as much as possible, the contributors to content knowledge that would affect the percent proficiency of students on the end of course exam.

There were 157 high school technology education teachers that represent all the teachers with a basic technology education teaching license and teach one of the five courses in the study. There are more licensed technology education teachers in the state, but the others have met additional criteria that eliminate them from the parameters of this study. The final sample includes 76 alternatively licensed teachers, 34 traditionally licensed teachers and 47 teachers that the NCDPI designated as both alternatively licensed and traditionally licensed. The teachers designated as having both types of licensure were eliminated for Research Question 1 since their specific licensure type cannot be determined. The test score results provided by NCDPI are reported in terms of the percent of students obtaining proficiency by course, and not teacher, for each course taught at a particular school. Therefore, if more than one teacher from the same school taught the same course, it could not be determined from the data which test results were achieved by which teacher, and these teachers were removed from the study. The teacher information is summarized in Table 1 (next page).

Table 1
Total Number of Teachers Based on Licensure Type

Course	Alternative	Traditional	Total
All Five Combined	55	26	81
Fund. of Tech.	44	18	62
Communication	13	7	20
Manufacturing	7	5	12
Structural	10	11	21
Transportation	11	8	19

At this point, the data were analyzed to determine if there were any statistically significant differences in the overall percent proficiency of students with all five courses combined and then for each of the five courses separately. Since the systems courses are more skills and trade-based, the researcher felt this will be a valuable component of comparing the different licensure types. From this data set, a one-way ANOVA was conducted using the statistical software SPSS.

Research Question 2

A sub-sample of five teachers from each group was chosen from within the original sample. The smaller sample size permitted the capability of performing detailed video-taped observations to determine the percent of students' time on task during the delivery of a typical classroom lesson. In this study, a typical lesson was not defined but the researcher but was left up to the teacher to decide how they normally conduct a class period. This gives the researcher the best opportunity to record the natural tendencies of classroom settings and management techniques performed by the teacher. Prior research has shown that increasing a student's time on task will increase the opportunity for achievement (American Association of School Administrators, 1982; Biderman, Nguyen, & Sebren, 2008; Berliner, 1990; Brandt, 1982; Heck, 2007; Hines, Kromrey, Swarzman, Mann, & Homan, 1986; Huitt & Segars, 1980; Opdenakker & Damme, 2006; Prater, 1992, Seifert & Beck, 1984). This research project used the time on task of students as one measure of comparing the effectiveness of alternatively licensed and traditionally licensed technology education teachers. As previously mentioned, there were 157 high school technology education teachers that teach either Fundamentals of Technology or one of the four systems courses. For this portion of the study, the teachers that were shown to have both an alternative license and a traditional license were kept on the list. If one of these teachers participates in this portion of the study, their licensure type was verified by the researcher. If their licensure type could not be determined, they were ineligible for the study. Also, in order for a teacher to be eligible for this portion of the study, both the teacher and the teacher's principal had to agree to participate. If either the teacher or principal did not agree to participate, this teacher was no longer considered eligible for the study and another teacher was contacted. When both the teacher and principal agreed to be in the study, the researcher verified the teacher's licensure type. This process was continued until there were five pairs of teachers and principals from each licensure type. Surveys were completed by the selected teachers to collect demographical and background information. The results for some of the survey questions are shown in Table 2 for alternatively licensed teachers and Table 3 (next page) for traditionally licensed teachers.

Table 2
Survey Results for Alternatively Licensed Teachers

	Participant				
Question	1	2	3	4	5
Years Teaching HS Tech Ed	5	4	6	10	6
Other Certification Areas	No	Elementary Ed; Trade & Industrial	No	Business Ed; Trade & Industrial	Trade & Industrial
Other Areas of Teaching Experience	3 years exceptional children	No	4 years micro-computer applications at University	10 years Business Ed, (along with Tech Ed)	26 years Trade & Industrial
Degrees Earned	BS Science	BS Science	BS Engineering, MS Manuf. Technology	BS Math, BS Computer Science, MS Engineering	BS Science
Any University courses in pedagogical management	No	No	No	No	No
Other work Experience	3 years residential construction, 3 years commercial construction	10 years residential construction	4 years furniture product development	5 years systems analyst	No

Table 3
Survey Results for Traditionally Licensed Teachers

Question	Participant 1	2	3	4	5
Years Teaching HS Tech Ed	26	15	18	20	16
Other Certification Areas	Trade & Industrial	Electronics; Metals	No	Trade & Industrial	No
Other Areas of Teaching Experience	15 years Trade & Industrial	5 years Industrial on-line at Univ.	No	12 years Trade & Industrial	No
Degrees Earned	BS Tech Ed	BS Tech Ed	BS Tech Ed	BS Tech Ed	BS Tech Ed
Any University courses in pedagogical management	Differentiated instruction; Varied delivery methods	Differentiated instruction; Varied delivery methods; Knowledge of different learning styles	Differentiated instruction; Varied delivery methods; Behavior management	Formative assessment to drive teaching methods; Project-based unit development	Behavior management
Other work Experience	Satisfactory; Wants to see greater desire for improving teaching methods	Satisfactory; Improve diversified instruction and varied use of technology	Satisfactory; Increase varied use of technology; Improve behavior management	Satisfactory	Excellent

This portion of the research used video recordings of the first 45 minutes of a classroom lesson by each of the ten teachers. Each video showed a wide angle view of the classroom so the researcher could see all the students during the entirety of the lesson. The time on task, as defined by the amount of time the student was engaged in the lesson plan as directed by the teacher, is reported as a numerical value of the percentage of students on task at three minute intervals, beginning five minutes after the start of class. This method of interval observations provides an opportunity for the teacher to transition among different teaching techniques and lesson plan activities (Allday, Duhon, Blackburn-Ellis, & Van Dycke, 2011; Colvin, Flannery, Sugai, & Monegan, 2009; Sindelar, Daunic, & Rennells, 2004). When the observer takes measurements at different increments, the observer records a better overall summary of different classroom settings and teacher behaviors, and the results of time on task measurements can be more generalized for that class period (Colvin et al., 2009; Hines et al., 1986). The interval observation instrument, which was specifically designed for a classroom observational study, was taken from work performed by Colvin et al., which was tested to a reliability of 0.93. Using SPSS, a one-way ANOVA was performed to determine if there were any statistically significant differences between the time on task of students for the two groups of teachers.

The classroom setting and teacher behavior was also recorded at each interval. The researcher performed a repeated measures analysis to determine if there were any statistically significant differences in the time on task of students within each classroom setting and teacher behavior. A repeated measures analysis is appropriate when the same main effect is being tested from exposure to different conditions (Field, 2008; Lix & Sajobi, 2010). Time on task was the dependent variable in both groups, but was being measured under different conditions at constant intervals. These different conditions were the classroom setting and teacher behavior. This would explain if certain classroom settings or teacher behaviors have the ability to maintain a higher on-task rate of students when comparing the two groups of teachers.

Research Question 3

Administrator's opinions are very important since their decisions can drastically change the direction of a technology education program (Jewell, 1995). In a study conducted by Jewell, North Carolina principals generally supported the need for technology education courses in all high schools. This same study also points out principals were found to have a high regard for the effectiveness of technology education teachers in general classroom management and content delivery (Jewell, 1995). The current research study is building on these findings and attempts to compare the principals' perspective on teacher effectiveness when comparing alternatively licensed and traditionally licensed technology education teachers. Research Question 3 involves audio-recorded telephone surveys with the principals of the teachers included in Research Question 2. The surveys were transcribed and reported as qualitative data, combining similar responses into various categories. This survey summarizes the principals' perceptions of the preparation, performance, and professional development needs of the two different groups of teachers.

Results

Research Question 1

The descriptive statistics for the five courses combined as well as each of the individual courses is shown in Table 4 (next page). A one-way ANOVA was performed on the data set, and Table 5 (next page) shows results of the statistical analysis. All of the analyses passed the test for homogeneity of variances, meaning the variances of the two samples were not significantly different for each course taught. The results show there were no significant differences in the percent of students obtaining proficiency between the two groups of teachers for all five courses combined and each of the five courses individually.

Table 4
Descriptive Statistics for Number of Teachers and the Percent Proficiency of Students

Course	Licensure	N	Mean	Std. Dev.	Min.	Max
All Five Combined	Alternative	55	76.61	14.79	38.28	100.0
	Traditional	26	78.34	17.48	30.77	100.0
Fund. of Tech.	Alternative	44	75.55	15.01	33.33	97.80
	Traditional	18	77.74	18.14	30.77	97.22
Communication	Alternative	13	81.23	17.70	30.30	100.0
	Traditional	7	74.65	21.69	50.00	100.0
Manufacturing	Alternative	7	76.32	21.41	47.73	100.0
	Traditional	5	84.25	9.65	75.00	100.0
Structural	Alternative	10	80.19	19.23	45.83	100.0
	Traditional	11	76.99	23.15	33.33	100.0
Transportation	Alternative	11	78.26	17.27	52.63	100.0
	Traditional	8	84.87	18.40	47.37	100.0

Table 5
One-Way ANOVA for Percent Proficiency of Students

Course	DF	Mean Square	F	P-value
All Five Combined	1	53.82	0.219	0.641
Fund. of Tech.	1	61.33	0.241	0.625
Communication	1	197.06	0.539	0.472
Manufacturing	1	183.61	0.588	0.461
Structural	1	53.38	0.117	0.736
Transportation	1	202.43	0.643	0.434

Research Question 2

Time on task. Using SPSS, a one-way ANOVA was used to compare the average number of students on task between the two groups of teachers. The descriptive statistics of the results are shown in Table 6 (next page) and the results for the statistical analysis are shown in Table 7. The analysis passed the test for tests for homogeneity of variances, meaning the variance of the two samples were not significantly different. With a p = 0.755, there was no significant difference in the time on task of students between the two groups of teachers.

Table 6
Descriptive Statistics for Time on Task of Students

Certification	N	Mean	Std. Dev.	Min.	Max
Alternative	5	0.758	0.104	0.612	0.857
Traditional	5	0.775	0.049	0.693	0.817

Table 7
One-Way ANOVA for Time on Task of Students

	DF	Mean Square	F	P-value
Between Groups	1	0.001	0.104	0.755
Within Groups	8	0.007		
Total	9			

Classroom settings and teacher behaviors. Table 8 (next page) shows the qualitative aspects of how each teacher choose to use their instructional time by displaying the frequency of classroom settings and teacher behaviors used by each group of teachers. This data would have been used to help explain any statistically significant differences in the time on task of students between the two groups if one had existed. However, since there were no significant differences, this data can be used to show there were some qualitative differences in the teaching styles between the two groups of teachers that will be addressed in the discussion section.

Table 8
Frequency of Classroom Settings and Teacher Behaviors

	Alternative		Traditional	
Classroom Setting	Occurrences	Average	Occurrences	Average
Large Group	26	5.2	35	7.0
Small Group	12	2.4	23	4.6
Individual	31	6.2	11	2.2
Transition	1	0.2	1	0.2
Teacher Behavior				
Lecture	14	2.8	35	7.0
Activity	12	2.4	8	1.6
Project	33	6.6	24	4.8
Assessment	11	2.2	3	0.6

Due to the nature of the data, there were not enough different types of classroom settings and teacher behaviors to perform a repeated measures statistical test. Not all of the teachers exhibited all the different types of classroom settings and behaviors during their instructional time. Therefore, there were not enough data points to make this type of analysis valid.

Research Question 3

Research Question 3 was designed to determine if the principals of the participants in Research Question 2 have a different perception of the preparation, performance, and professional development needs when comparing alternatively licensed and traditionally licensed technology education teachers. The results of the survey for the principals of the alternatively licensed teachers are shown in Table 9 (next page), and the results of the survey for the principals of the traditionally licensed teachers are shown in Table 10. The responses to the survey questions have been categorized and grouped together based on similar responses by the principals.

Table 9
Survey Results for Principals of Alternatively Licensed Teachers

	Participant Principal				
Question	1	2	3	4	5
Years Admin	7	9	15	3	5
Years Principal	3	4	8	1	3
Years at Current School	3	2	8	1	3
Teach Ed Teachers Supervised	2	5	7	3	3
Teacher's Content Knowledge	Good	Very Good	Good	Very Good	Good
Teacher's Pedagogical Knowledge	Good	Average	Good	Excellent	Good
Varied Instructional Strategies	Below Average	Average	Good	Good	Excellent; Good use of various technologies and differentiated instruction
Exam Scores	Below Average	Average	Excellent	Average	Excellent
Professional Development Needs	Pedagogical knowledge; Varied delivery methods	Varied delivery methods; behavior management	Varied delivery methods	Differentiated instruction	None
Overall Teacher Effectiveness	Satisfactory; Room for improvement	Satisfactory	Satisfactory; Improve various instructional strategies and behavior management	Very satisfied; Good expertise	Satisfactory; Improve involvement with extra-curricular activities

Table 10
Survey Results for Principals of Traditionally Licensed Teachers

	Participant Principal				
Question	1	2	3	4	5
Years Admin	14	7	11	12	9
Years Principal	8	2	5	1	4
Years at Current School	6	2	5	1	2
Teach Ed Teachers Supervised	4	3	6	6	3
Teacher's Content Knowledge	Good	Good	Good	Excellent	Excellent
Teacher's Pedagogical Knowledge	Good	Average	Average	Average	Excellent
Varied Instructional Strategies	Needs Improvement	Needs Improvement	Average	Good	Very Good
Exam Scores	Needs Improvement	Average	Average	Good	Very Good
Professional Development Needs	Differentiated instruction; Varied delivery methods	Differentiated instruction; Varied delivery methods; Knowledge of different learning styles	Differentiated instruction; Varied delivery methods; Behavior management	Formative assessment to drive teaching methods; Project-based unit development	Behavior management
Overall Teacher Effectiveness	Satisfactory; Wants to see greater desire for improving teaching methods	Satisfactory; Improve diversified instruction and varied use of technology	Satisfactory; Increase varied use of technology; Improve behavior management	Satisfactory	Excellent

Discussion

The quantitative analysis of the experiment shows there were no significant differences between the two groups of teachers. There are several possible reasons why the statistical analysis shows there were no differences. The first is there may not be a significant difference between the two groups of teachers when comparing the percent of students proficient on the VoCATS. This would support the literature that says there are no statistically significant differences in teacher effectiveness when comparing alternatively licensed teachers and traditionally licensed teachers (Bradshaw & Hawk, 1996; Darling-Hammond et al., 2005; Feiman-Nemser, 1989; Hoepfl, 2001; Litowitz, 1998; Reese, 2010; Sindelar et al., 2004; Stoddart & Floden, 1995). Another reason a significant difference may not have been detected is because of the lack of power of the statistical analysis. Once the data filtration process was completed on the two groups of teachers, there were 55 alternatively licensed teachers and 26 traditionally licensed teachers for which to compare test scores. Although the sample sizes were large enough for a valid analysis, there were approximately 2.1 times more alternatively licensed teachers than traditionally licensed teachers. This difference in sample sizes causes a less powerful result and, therefore, creates less of a chance in discovering a statistically significant difference if one exists than if the sample sizes were equal (Guo & Luh, 2008; Tam & Wisenbaker, 1996; Wilcox, 1989).

Although there were no statistically significant differences, it is significant for the researcher when analyzing the qualitative differences and determining there is a need for looking more in-depth at these issues in future research. The two analyses with larger sample sizes were when all five courses were combined and Fundamentals of Technology. In both of these comparisons, the traditionally licensed teachers have slightly higher means. When considering the four systems, Communication Systems and Structural Systems had higher means for alternatively licensed teachers, while Manufacturing Systems and Transportation Systems had higher means for traditionally licensed teachers. Each of these means have greater differences than those of all five courses combined and Fundamentals of Technology. This could be due to smaller sample sizes and less powerful results. But, it raises the question of why some courses have a higher mean for alternatively licensed teachers and other courses have higher means for traditionally licensed teachers. Since the systems courses contain content that is more industry-related and skill-based, the researcher felt it was valuable to determine if industry experience could be a factor when analyzing the percent proficiency of students on the VoCATS exam when comparing the two groups of teachers.

Research Question 2

Time on task. Even though there were no significant differences between the ratios of students on task of the two groups of teachers, there were some qualitative observations significant to the researcher. The alternative licensed teachers had both the maximum and the minimum ratio of students on task during the observation intervals. This tells the researcher there are potentially some pedagogical management techniques that alternatively licensed teachers are using that are both more effective and less effective than the techniques used by traditionally licensed teachers. These are the kinds of differences the researcher was looking for and, therefore, evidence that more detailed research in this area would be beneficial.

Classroom settings and teacher behaviors. The qualitative analysis shows the traditionally licensed teachers used more large and small group settings with lecture, while the alternatively licensed teachers used more individual work with activities, projects, and assessments. As mentioned in the results, a repeated measures analysis was not performed on the classroom setting and teacher behaviors because the data were not complete enough for the results to have any statistical significance.

Research Question 3

Survey questions 1 through 4 were designed to gather background information about the principals' experiences as administrators. This tells how much experience each principal has working with technology education teachers. When one compares these results, the average years of experience for the principals of both groups of teachers are similar. Both groups have had approximately the same number of years of experience as administrators and have also had the opportunity to work with approximately the same number of technology education teachers. Survey questions 5 and 6 were designed to determine if the principals of the two groups of teachers had different perceptions of the teachers' curriculum content and pedagogical knowledge. When looking at the teachers' preparation, there were no significant differences in the principals' perceptions of the curriculum content and pedagogical knowledge between the two groups of teachers. Both groups of principals were pleased with the teachers' content knowledge in technology education.

Survey questions 7 and 8 are related to the principals' perceptions of the different types of instructional techniques used in the classroom to deliver the content. Overall, there was not a noticeable difference between the principals' perceptions of the use of different instructional techniques between the two groups of teachers. Concerning the teachers' end of year tests results on the VoCATS exam, one principal from each group of teachers was not satisfied. However, there were not any significant differences between the two groups of principals when commenting on their teacher's end of year test results.

Survey question 9 was designed to get the principals' perceptions on what they perceived as professional development needs of the teacher. The results show there were no significant differences between the two groups of teachers. However, the researcher would like to point out some of the differences that were mentioned. The only time that pedagogical knowledge was mentioned for a professional development need was for an alternatively licensed teacher. Behavior management was mentioned twice for traditionally licensed teachers and once for an alternatively licensed teacher. The need for increasing the variety of teaching methods was mentioned three times for both groups of teachers. Increasing the differentiation of instruction was mentioned three times for traditionally licensed teachers and once for alternatively licensed teachers. One interesting comment was the principal of a traditionally licensed teacher wanted to see more project-based learning to occur in the classroom. However, there were no observable significant differences among the responses. The researcher understands there is a need for all teachers to pursue professional development opportunities, and these results show that both alternatively licensed teachers and traditionally license teachers in technology education experience some of the same needs.

The last question gave the principals a chance to comment on how they felt about their teacher's overall effectiveness. By providing a general open-ended question, this gave the principals a chance to add other comments that were not specifically related to the previous questions in the survey. Every principal said they were satisfied with the effectiveness of their technology education teacher. In addition, some of the principals made extra comments about how they felt the teacher needed improvement in certain areas. Most of the areas of improvement were the same as mentioned in question 9 regarding professional development. One principal of an alternatively licensed teacher made a positive comment about how he or she appreciated the teacher's commitment to after school technology education related clubs and activities. However, there were no distinct differences in the comments made by the principals of both groups of teachers.

Conclusion

In this study, three research questions were used to provide a methodology for comparing the effectiveness of alternatively licensed and traditionally licensed technology education teachers in North Carolina. As discussed earlier, current research shows there is mixed data when comparing the effectiveness of alternatively licensed teachers compared to traditionally licensed teachers. This study was designed to build off this existing research and examine how these two groups of teachers compare to each other in technology education in North Carolina. By using the methodology in this study, the researcher was able to provide evidence that there may not be any statistically significant differences between alternatively licensed and traditionally licensed technology education teachers in North Carolina concerning the percent of students proficient on the end of year VoCATS exam, the time on task of students, and the principals' perceptions of the teachers' effectiveness. Supporters of each type of licensure program argue both licensure types produce competent teachers and having two different routes are likely to produce teachers with different expertise and skill sets (Feiman-Nemser, 1989; Stoddart and Flodon, 1995).

More empirical data needs to be provided for comparing alternatively licensed and traditionally licensed technology education teachers when measuring student achievement in North Carolina. Technology education is a field that ranges from having trade-related curriculums to courses more focused on the academic aspect of the design process. The content knowledge required to accommodate this range of knowledge lends itself to using characteristics of both alternatively licensed and traditionally licensed teachers (Darling-Hammond et al., 2005; Bradshaw & Hawk, 1996). The researcher believes that both types of licensure provide value to the technology education classroom. Each type of licensed teacher offers a distinct set of skills and knowledge that create unique learning opportunities for students. If the characteristics of what makes technology education teachers more successful in the classroom are better understood, then alternatively licensed teachers can be more supported as well as improving traditional preparation programs.

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