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Bits and Pieces

Looking at 2010

As 2009 draws to a close, it also marks the end of my first year as the editor of JITE. During this past year I have been talking a lot about change, and although you might not have seen much of a change on the outside for volumes 46-1, 46-2 or 46-3, there were many changes behind the scenes that contributed to each volume. Starting with volumes 47-1 (2010) you will see most of the changes that we (the NAITTE Board of Directors and JITE staff) have been working on during 2009 to help reach a larger audience. The most notable change you will see will be the JITE name and cover page. Look for this in the next volume. The Journal has expanded in scope to cover Science, English, Technology, and Math (STEM). Does this look familiar? It should as this is the wave of the future and we will be moving into the future to meet the needs of our readers. Other not so noticeable changes will be a new associate editor who will become editor next year, plus we will be consolidating most of the JITE business operations to one central location. This will be one person or organization who will handle the daily operational duties such as new member requests, membership records, back issues, and mailing labels for libraries.

I am really excited and looking forward to the New Year and all the changes that will be taking place to move this Journal into the future. I appreciate all the hard work by everyone involved to make it happen. Stay tuned for the future, it will be exciting.

In This Issue

Volume 46-3 starts out with the final part in a three part series written by Todd R. Kelley and Robert C. Wicklein titled *Examination of Engineering Design in Curriculum Content: Teachers Challenge to Implement Engineering Design in Secondary Technology Education.* In this manuscript the authors will answer the question, what selected challenges and barriers are indentified by secondary technology educations in order to teach engineering design? In parts one (Volume 46-1) and two (46-2) the authors provided readers with new curriculum options for technology education teachers to infuse engineering concepts into technology classrooms.

To go along with the Kelley and Wicklein article on curriculum content in technology education, the manuscript by Nathan Mentzer and Kurt Becker *Motivation while Designing in Engineering and Technology Education Impacted by Academic Preparation,* talks about their study which deals with changing motivation in a high school engineering design class. The elements of engineering design were taught to eleventh grades from diverse backgrounds. Assessments were given to measure student's motivation to apply critical thinking skills and reasoning to solve problems in five subscales: mental focus, learning orientation, creative problem solving, cognitive integrity and scholarly rigor.

While the previous authors did research in curriculum development, Umundadi Kennedy did his research in a manuscript titled *A Correlation Study of Students Achievement in Television* in which he studied the relationship between male and female students' academic achievement in the television subject field in rural technical colleges located in the Delta

State. The main purpose of this research was to provide youth with useful skills and improve their knowledge in their desired skill areas.

Studying learning styles of students has been very important to the previous authors and the manuscript titled *A Cross-Case Analysis of Gender Issues in Desktop Virtual Reality Learning Environments* is no exception. The authors writing the manuscript, Lynna Ausburn, Jon Martens, Andre Washington, Debra Steel, and Earlene Washburn, examined gender-related issues using a new desktop virtual reality technology as a learning tool in career in technical education. The authors used two studies to address gender issues in virtual reality training. The findings in this study suggest that males and females may be differently affected by virtual reality environments and this information should affect implication of future virtual learning environments for Career and Technical programs.

In a continuing effort to provide Career and Technical Education professionals with additional insight on how to better meet the needs of the learners, Richard A. Walter and Mark Threeton wrote a manuscript *Automotive Technology Student Learning Styles and Their Implications for Faculty*. Their research provides Career and Technical professionals with insight on how to better meet the educational needs of the learner and identified the students' preferences for learning while enrolled in postsecondary automotive programs.

In an At-Issue article written by Michael Kroth, *Improving Your Teaching: Using Synergistic Andragogy*, the author tells about an alternative mode of education where students are formed into small teams and learn from one another through structured interactions.

Volume 46-3 ends with an Under Review report written by Ray Carson, who reviewed *Leadership and Self-Deception*, by the Arbinger Institute (2000). It's a must read for educators, Ray Carson says that everyone in education will benefit from the concepts presented in the book. Educators must be able to interact and communicate but may not be effective without understanding how to avoid self-deception.

As you read though the manuscripts presented in Volume 46-3 you can see the authors' main goals are to make learning more meaningful for students and educators. I would hope that you, as readers, will be able to take the information presented and adopt it into your teaching styles.

I hope everyone has a great and successful 2010 and I am looking forward to working with you.

Automotive Technology Student Learning Styles and Their Implications for Faculty

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Abstract

In an effort to provide Career and Technical Education (CTE) professionals with additional insight on how to better meet the educational needs of the learner, this study sought to identify the preference for learning of postsecondary automotive technology students. While it might appear logical to naturally classify auto-tech students as primarily hands-on-learners, the results suggested that the sample was a diverse group of learners with specific educational preferences within the automotive technology program. With a lack of learning style research within the trade and industry sector of CTE, findings may be useful to trade and industry teachers and or teacher educators interested in diversifying curriculum and instruction via strategies to enhance the educational experience for the student learner.

Historical Perspectives

Over the years, many students have had a teacher from whom it was difficult to learn. This difficulty may have been

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related to a lack of student interest in the curriculum, or it could have been that the subject was taught in a manner that didn't correspond with the student's preference for learning. According to Gardner, (1999) educators tend to teach the way they were taught. Moreover, Jonassen (1981) identified that a strong relationship exists between a teacher's learning style and his or her preferred teaching style. Unfortunately, there is not a "one-size fits all" approach to teaching and or learning (Jorgensen, 2006). Thus, this creates a problem that requires attention.

"It is clear that a learning style body of knowledge has been accepted into the education literature and professional development agenda since the 1980s" (Hickcox, 2006, p. 4). A large portion of past research has focused on identifying learning styles, personality types, intelligence and/or adaptive strategies of teaching to meet the learning needs of students. However, this research does not, in most cases, specifically align with a Career and Technical Education (CTE) setting. For this reason, it may be difficult to fully comprehend the relevance of learning style literature to CTE without highlighting its importance.

Learning Styles and their Importance

While not specifically targeted to CTE, there is a vast amount of literature surrounding the topic of learning style, which is relevant in all educational contexts. Kolb, (1984) defined learning as a "process whereby knowledge is created through the transformation of experience" (p.38). A learning style on the other hand is defined as a "mode and/or environment(s) in which individuals learn most effectively and efficiently" (Howell & Wikoff, 1984, p. 119). Sims and Sims (2006) explained that the phrase learning style is often used interchangeably with terms such as "cognitive style," "learning ability," and techniques for assessing individuals "learning characteristics."

There is not a "one-size fits all" approach to teaching and or learning (Jorgensen, 2006). However, Hartel (1995) identified that an educator's teaching style is often determined by his or her own learning style rather than by the learning style of the pupil. A study by Jonassen (1981) identified that a strong relationship exists between the learning style of an educator and his or her preferred teaching style. Additional literature has revealed that educators cannot provide a substantial reason as to why they utilized a particular teaching and or learning style technique (Barkley, 1995). While findings such as these could be considered alarming, Whittington and Raven (1995) suggested that teaching styles can be altered with conscious effort. Heimlich and Norland (1994) indicated that:

> It is often asserted that educators should adapt their teaching style to the learning style of the students. This advice appears to be a contradiction of the basic meaning of style, which is a function of an individual's personality, experience, ethnicity, education and other individual traits. An educator cannot and should not "change" personality to satisfy each and every learner. Instead, the teacher can adopt - and - adapt classroom methods, strategies, techniques, and processes to be more consistent with his or her individual style (p. 45).

With this "adopt - and - adapt" principle in mind, several studies have provided a pragmatic look at such a concept. Ausburn and Brown (2006) noted that "studies of individual differences in preferred instructional methods and approaches to learning have shown that student learning tends to benefit from identifying such differences and from using them to customize instruction" (p. 17). An example of this includes a meta-analysis of 42 studies conducted between the

1980s and 1990s which found a positive relationship between academic achievement and instruction that matched students' learning styles (Dunn Griggs, Olsen, Gorman, & Beasley, 1995). Another study by Munday (2002) found that knowledge of the learning strategy preference enhanced academic performance, and as a result, is beneficial to adult students as well as the instructor.

These studies have served to highlight the vast amount of research conducted on learning styles. This literature reinforces the importance of the topic of learning styles and personal differences in the teaching and learning process. While the related literature does not specifically align with a CTE setting, educators within the profession should take this information seriously as comprehending learning style characteristics has the ability to enhance the educational experience for the learner.

The Problem

According to Gardner (1999), teachers tend to teach the way they were taught. Jonassen (1981) identified that a strong relationship exists between a teacher's learning style and preferred teaching style. These critical findings present a problem that requires attention as we do not all come from the same mold in regard to our specific learning style or personality. Hickcox (2006) suggested that all learning style research and application efforts should stress the development of the individual and the whole learner. Therefore, learning styles should be accounted for when considering the topic of curriculum development and instruction. With the overload of curricular assessment demands, and the numerous learning style models, educators may find themselves in a state of confusion regarding the use of learning style models in the classroom (Hickcox, 2006).

Purpose and Research Questions

While several studies have examined student-learning styles within education, few have examined this topic in the trade and industrial sector of CTE. Thus, this study sought to identify the learning styles of postsecondary automotive technology students, and determine whether there is an association between the students' learning styles and selected background information: (a) years of auto-tech work experience, (b) high school auto-tech course completion, and (c) postgraduate career plan. This topic was examined for the purpose of providing more information regarding how to better serve the educational needs in preparing this student population for the world-of-work. Therefore, this study sought to answer the following questions:

1. What is the learning style distribution of postsecondary automotive technology students?
2. Is there an association between the students' learning styles and their postgraduate plans to pursue an automotive technology career?
3. Is there an association between the students' learning styles and their automotive technology work experience since age 16?
4. Is there an association between the students' learning styles and their completion of a high school auto-tech course?

Theoretical Framework

Over the years, the topic of learning has been examined extensively and has received considerable attention in scholarly journals as well as the popular press. A large portion of this past research has focused on the concept of experiential learning, generally used by educators to describe a series of pragmatic activities sequenced in such a way that it is thought to enhance the educational experience for the student learner. Therefore, the theoretical framework utilized in this CTE focused research study was Kolb's Experiential Learning Theory (ELT). Kolb's ELT has steadily gained acceptance and popularity in education and serves as an invaluable resource for teaching and learning (Kolb & Kolb, 2006). Kolb draws upon the works of Dewey, which stressed the role of experience in the learning process (Rudowski, 1996). Thus, this learning model is grounded in the theoretical framework of personal experience (Ausburn & Brown, 2006). Kolb's ELT is built on six propositions (Kolb & Kolb, 2005) that include:

(a) Learning is best conceived as a process, not in terms of outcomes. To improve learning in higher education, the primary focus should be on engaging students in a process that best enhances their learning, a process that includes feedback on the effectiveness of their learning efforts.

(b) All learning is relearning. Learning is best facilitated by a process that draws out the students' beliefs and ideas about a topic so that they can be examined, tested, and integrated with new, more refined ideas.

(c) Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Conflict, differences, and disagreement are what drive the learning process. In the process of learning one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking.

(d) Learning is a holistic process of adaptation to the world. Not just the result of cognition, learning involves the experiential integrated functioning of the total person; thinking, feeling, perceiving, and behaving.

(e) Learning results from synergetic transactions between the person and the environment.

(f) Learning is the process of creating knowledge (p. 194).

Kolb's ELT (1984) identified two dialectically related modes of grasping experience: Concrete Experience (CE) and Abstract Conceptualization (AC); and two dialectically related modes of transforming experience: Reflective Observation (RO), Active Experimentation (AE). Based on the preferences for one of the polar opposites of each of the aforementioned modes appears four learning styles including: (a) Converging, (b) Diverging, (c) Assimilating and (d) Accommodating (Evans, Forney & Guido-Dibrito, 1998) (see Figure 1). Kolb's ELT naturally aligned with this study and its focus on the learning styles, and preferences for learning, of postsecondary automotive technology students.

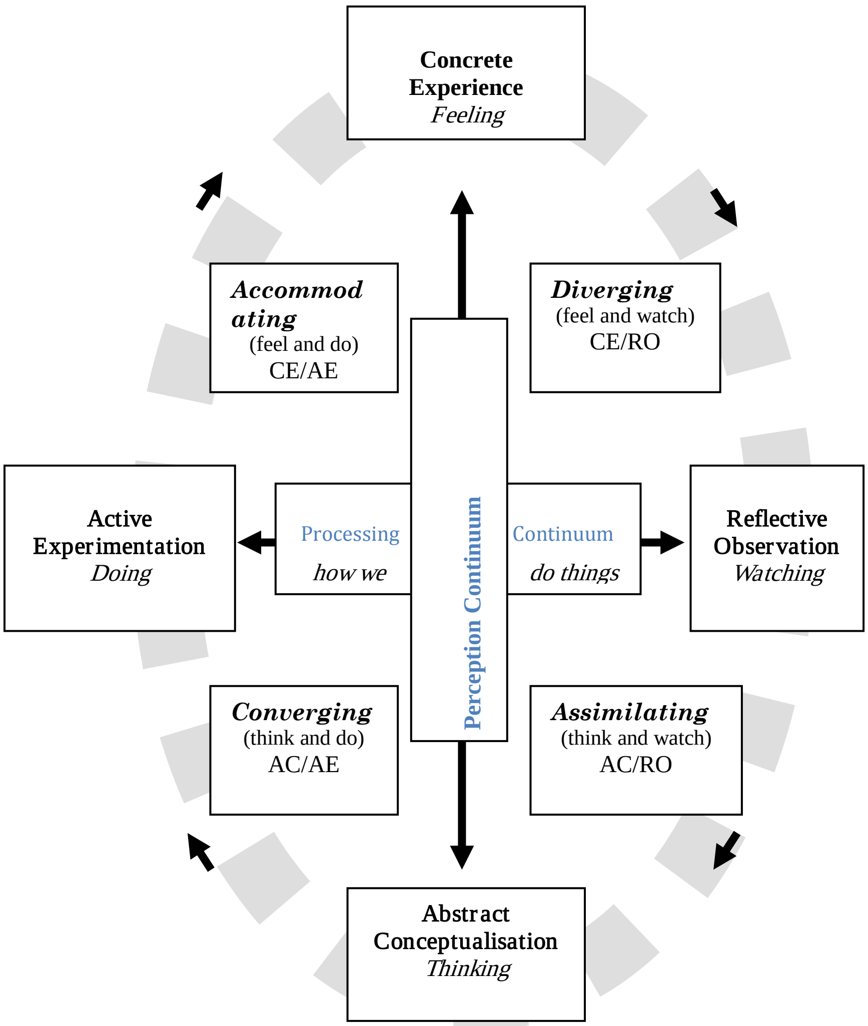

Figure 1. Kolb's learning styles (Chapman, 2006).

Methods

Kolb's ETL uses an instrument known as the Learning Style Inventory (LSI) to assess individual learning style and preference for learning. The LSI is set up in a simple format, which usually provides an interesting self-examination and discussion, that identifies valuable information regarding the individual's approaches to learning (Kolb & Kolb, 2005). Table 1 presents the LSI technical manual normal distributions of undergraduate, graduate students and adult learners according to their learning style classifications and particular educational specialization as observed after completing the assessment.

Table 1
Distribution of Learning Style by Educational Specialization (n=4679)

	Learning Style			
Educational Specialization	Accommodating	Diverging	Converging	Assimilating
Accounting	39 (26.2%)	26 (17.4%)	42 (28.2%)	42 (28.2%)
Agriculture	6 (31.6%)	6 (31.6%)	6 (31.6%)	1 (5.3%)
Architecture	2 (28.6%)	0 (0%)	1 (14.3%)	4 (57.1%)
Business	290 (31.2%)	165 (17.8%)	215 (23.1%)	259 (27.9%)
	54 (49.1%)	17 (15.5%)	20 (18.2%)	19 (17.3%)
Computer Sci./IS	54 (26.2%)	35 (17%)	55 (26.7%)	62 (30.1%)
Education	92 (38.3%)	46 (19.2%)	41 (17.1%)	61 (25.4%)
Engineering	103 (23.6%)	50 (11.5%)	145 (33.3%)	138 (31.7%)
App. & Fine Arts	23 (30.7%)	20 (26.7%)	12 (16%)	20 (26.7%)
Health	82 (31.4%)	48 (18.4%)	59 (22.6%)	72 (27.6%)
Humanities	28 (25.2%)	24 (21.6%)	19 (17.1%)	40 (36%)
Language	8 (30.8%)	4 (15.4%)	5 (19.2%)	9 (34.6%)
Law	29 (26.4%)	16 (14.5%)	23 (20.9%)	42 (38.2%)
Literature	5 (13.2%)	15 (39.5%)	8 (21.1%)	10 (26.3%)
Medicine	88 (27.8%)	50 (15.8%)	96 (30.4%)	82 (25.9%)
Other	301(31.8%)	213 (22.5%)	185 (19.5%)	248 (26.2%)
Phys. Education	12 (50%)	5 (20.8%)	3 (12.5%)	4 (16.7%)
Psychology	53 (33.1%)	40 (25%)	15 (9.4%)	52 (32.5%)
Science/Math	53 (18.5%)	35 (12.2%)	88 (30.8%)	110 (38.5%)
Social Sciences	68 (29.7%)	51 (23.3%)	38 (16.6%)	72 (31.4%)
Total	1390 (29.7%)	866 (18.5%)	1076 (23%)	1347 (28.8%)

(Kolb & Kolb, 2005a, p 71)
Note. The sample within this table includes both undergraduate college students, graduate students and adult learners with an approximate age range of <19 to >55.

Target Population

The target population for this study was postsecondary automotive technology students in the central region of Pennsylvania (i.e., from New York to Maryland), and was defined as: (a) first or second year students currently enrolled in a postsecondary automotive technology program providing career preparation in the automotive technology field (i.e., general certificate programs, associate of applied science degree programs, and automotive manufacturer GM Asset programs); (b) students currently learning, through a combination of classroom instruction and hands-on experience, to repair automobiles, trucks, buses, and other vehicles; and (c) currently enrolled students who are at least 18 years of age.

During the data collection phase of this study, there were three public postsecondary colleges with automotive technology programs in the central region of Pennsylvania. According to these institutions' offices of the Registrar, during the spring semester 2008, there were a total of 310 postsecondary automotive technology students in central Pennsylvania. Therefore, a minimum sample size of 172 was required for the study to represent the population with no more than a 5% margin of error with 95% confidence (Isaac & Michael, 1997). To secure an acceptable sample size, the surveys were administered by the primary investigator during sessions held in the participating postsecondary automotive technology students' regular community college classrooms.

Instrumentation

A quantitative research methodology was used to conduct the study with data collection accomplished through two paper form questionnaires. The first focused on participant demographic information through a series of questions relating to: (a) gender, (b) age, (c) career plan, (d) automotive work experience, (e) secondary auto-tech course completion, and (f) program satisfaction. The second was Kolb's Learning Style Inventory (LSI).

Validity and reliability for LSI

Kolb's ELT uses a self-administered, scored and interpreted educational assessment instrument, the Learning Style Inventory (LSI), to assess individual learning style, which was utilized in the study (3.1 Version). Smith and Kolb (1986) identified the reliability Cronbach alpha coefficients of the LSI as ranging from .73 to .88. Watson and Bruckner (Evens et al., 1998) found the reliability Cronbach alpha coefficients of the LSI ranged from .76 to .85. While the LSI appears to be a reliable assessment tool yielding internally consistent scores, Kolb (1976) has suggested the best measure of his instrument is not reliability but rather construct validity. As an example, Ferrell (1983) conducted a factor-analytic comparison of four learning style instruments and determined a match was present between the factors and learning style on the original LSI contributing to construct validity. Furthermore, Evans et al. (1998) noted construct and concurrent validity of the LSI have received several endorsements.

Data Collection

The data collection phase of this study was conducted during the spring of 2008 at the three public postsecondary institutions in central Pennsylvania offering automotive technology as a program of study. The appropriate clearance was obtained from the Pennsylvania State University Office for Research Protections regarding the inclusion of human subjects in this research study. Access was also granted by the automotive technology faculty members at the participating institutions. These faculty members selected specific automotive technology classes to participate in this study for a total of 189 potential research participants. Faculty members allotted 90 minutes of class time for data collection.

Beginning in January of 2008, 13 face-to-face data collection sessions were conducted with automotive technology students at the three institutions. After a brief introduction and explanation of the research purpose, students were invited to participate in the study. The students were informed that participation was voluntary and their identity would be kept confidential. A signed informed consent form was obtained from each participating student prior to his or her completion of the survey instruments. The participants were instructed to first complete the general background information survey. Second, students were asked to complete the LSI (3.1 Version) instrument. Third and finally, participants were extended a thank you as the primary investigator collected the survey packets from each student.

Rate of Return

The face-to-face data collection sessions yielded 188 participants/instruments (i.e., 99% response rate) or approximately 60% of the total population. However, 12 survey packets were removed from the study due to incomplete information. Thus, the total count of usable instruments within this study was 176 or 56.7% of the target population. The usable response rate from the sample of 189 subjects was 93%.

Analysis of Data

The first research question was answered by calculating the frequencies and percentages of the learning style data collected from the completed LSI instruments. Next, the second research question was answered by calculating the frequencies and percentages of the data collected from the background information survey. Finally, the remaining two research questions were answered through a series of Chi-square cross tabulations examining the association between the students' learning styles and selected background information: (a) years of auto-tech work experience, (b) high school auto-tech course completion, and (c) career plan. All data were analyzed using the Statistical Package for the Social Sciences (SPSS v16, 2008).

Background of Participants

Demographic data were collected from participants via six questions regarding gender, age, career plan, automotive work experience, secondary auto-tech course completion status, and current program satisfaction. Table 2 summarizes the demographic data collected from the background information survey.

Table 2
Demographic Data of Participants
(n=176)

	n	%
Gender		
Male	173	98
Female	3	2
Age of Participants		
18-20 yrs.	141	80
21-23 yrs.	24	14
24-26 yrs.	4	2
27-30 yrs.	2	1
31-45 yrs.	5	3
Plan to Pursue a Career in Auto-Tech		
Yes	166	94
No	10	6
Years of Auto-Tech Work Experience Since Age 16		
None	31	18
< 1 yrs.	43	24
1-5 yrs.	98	56
6-10 yrs.	2	1
11-15 yrs.	0	0
16 or > yrs.	2	1
Completed an Auto-Tech Course in High School		
Yes	55	31
No	121	69
Overall Satisfaction with Current Auto-Tech Program		
Very Satisfied	90	51
Moderately Satisfied	82	47
Low Satisfaction	4	2
No Satisfaction	0	0

Findings

Research Question 1

The first research question focused on identifying the learning style distribution of postsecondary automotive technology students and was answered by calculating the frequencies and percentages of the learning style data collected from the completed LSI instruments. The results revealed that all learning styles were represented within the sample. The Accommodating style was most highly represented (39.8%), while the Assimilating was the least (16.5%), suggesting that the sample of postsecondary automotive technology students was a diverse group of learners (see Table 3).

Table 3
Distribution of Participant Learning Styles (n = 176)

Learning Style	*n*	%
Accommodating	70	39.8
Diverging	37	21
Converging	40	22.7
Assimilating	29	16.5
Total	176	100

Note. (a) Accommodating people have the ability to learn primarily from hands-on experience; (b) Diverging people are best at viewing concrete situations from diverse points of view; (c) Converging people are best at finding practical uses for ideas and theories; and (d) Assimilating people are best at understanding the information and putting it into logical form (Kolb & Kolb, 2005b).

The basic descriptive statistics calculated from the completed LSI further revealed: (a) 70 (39.8%) participants identified as Accommodating had a CE and AE preference for learning; (b) 37 (21%) participants identified as Diverging had a CE and RO preference for learning; (c) 40 (22.7%)

participants identified as Converging had an AE and AC preference for learning; and (d) 29 (16.5%) participants identified as Assimilating had a RO and AC preference for learning (see Figure 2).

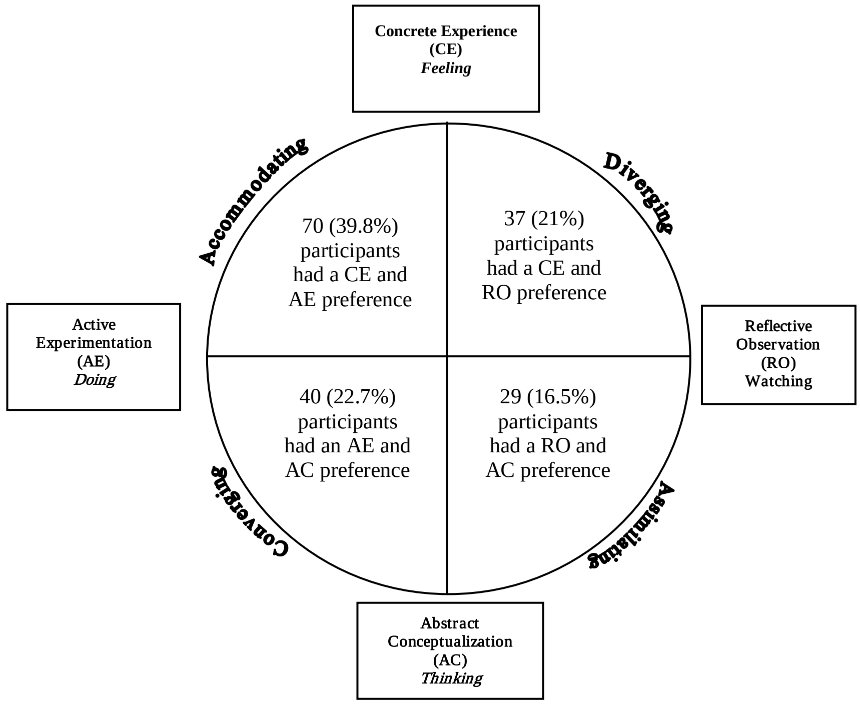

Figure 2. Preference for learning distribution of Participants.

Research Question 2

The second research question focused on associations between the students' learning styles and postgraduate plans to pursue an automotive technology career, and was answered using a Chi-square cross tabulation consisting of a 4x2 analysis between the four learning styles, and postgraduate plans. The results revealed no statistically significant association between the learning styles and whether participants planned to pursue an auto-tech career (see Table 4).

However, the basic descriptive statistics in Table 4 reveal an overwhelming majority (166 of 176) of the students were planning to pursue a postgraduate auto-tech career. Of those planning to pursue an auto-tech career, 66 (40%) were Accommodating style, 35 (21%) Diverging, 38 (22.8%) Converging, and 27 (16.2%) Assimilating. Of the 10 students not planning to pursue an auto-tech career, 4 (40%) were Accommodating style, 2 (20%) Diverging, 2 (20%) Converging, and 2 (20%) Assimilating.

Table 4
Crosstabulation of Learning Style by Auto Tech Career Plan Status (n = 176)

	Do you Plan to Pursue an Auto Tech Career?	
Learning Style	Yes	No
Accommodating	66 (40%)	4 (40%)
Diverging	35 (21%)	2 (20%)
Converging	38 (22.8%)	2 (20%)
Assimilating	27 (16.2%)	2 (20%)
Total	166 (100%)	10 (100%)

$\chi 2(3,N=176)=.120$, $p=.989$.
Note. 4 cells (50.0%) have expected counts less than 5. The minimum expected count is 1.65.

Research Question 3

The third question focused on identifying any association between the students' learning styles and their automotive technology work experience since age 16, and was answered using a Chi-square cross tabulation consisting of a 4x2 analysis between the four learning styles and automotive technology work experience since age 16. The Chi-square cross tabulation revealed that there was a statistically significant association between those with auto-tech experience since age 16 and learning style (see Table 5).

In examining the percentages within the experience versus no experience, the primary investigator noticed the following patterns. First, participants with work experience, by a ratio of approximately 2 to 1, were accommodating style learners. Second, those with no experience, by slightly more than a 2 to 1 ratio, were Assimilating style learners as compared to experienced Assimilating learners. As detailed within Table 5, the majority of the participants (145 of 176) had auto-tech experience since they were 16 years of age including 63 (43.5%) Accommodating style learners, 28 (19.3%) Diverging, 35 (24.1%) Converging, and 19 (13.1%) Assimilating. Only 31 had no work experience, the majority of whom, ten (32.3%), were classified as Assimilating style learners followed by Diverging style with nine (29%).

Table 5
Crosstabulation of Learning Style by Work Experience Status (n = 176)

	Auto Tech Work Experience Since Age 16	
Learning Style	No Experience	Experience
Accommodating	7 (22.6%)	63 (43.5%)
Diverging	9 (29%)	28 (19.3%)
Converging	5 (16.1%)	35 (24.1%)
Assimilating	10 (32.3%)	19 (13.1%)
Total	31 (100%)	145 (100%)

$\chi 2(3,N=176)= 1.03$, p =.016, Cramer's V=.016.
Note. 0 cells (.0%) have expected counts less than 5. The minimum expected count is 5.11.

Research Question 4

The fourth question focused on identifying any association between the students' learning styles and completion of an automotive technology course in high school, and was answered using a Chi-square cross tabulation consisting of a 4x2 analysis between the four learning styles and whether participants had completed an automotive technology course in high school. The results revealed no statistically significant association between learning styles and completion of a secondary auto-tech course (see Table 6).

As displayed within Table 6, a majority of the participants (121 of 176) did not complete an auto-tech course in high school, including 46 (38%) Accommodating style learners, 26 (21.5%) Diverging style, 25 (20.7%) Converging style, and 24 (19.8%) Assimilating style. Only 55 completed an auto-tech course in high school, of which 24 (43.6%) were classified as Accommodating style, followed by 15 (27.3%) Converging style learners.

Table 6
Crosstabulation of Learning Style by Secondary Auto Tech Course Completion Status (n = 176)

	Did you Complete a Secondary Auto Tech Course?	
Learning Style	Yes	No
Accommodating	24 (43.6%)	46 (38%)
Diverging	11 (20%)	26 (21.5%)
Converging	15 (27.3%)	25 (20.7%)
Assimilating	5 (9.1%)	24 (19.8%)
Total	55 (100%)	121(100%)

$\chi 2(3, N=176) = 3.71$, $p = .294$.
Note. 0 cells (.0%) have expected counts less than 5. The minimum expected count is 9.06.

Conclusions and Discussion

In an effort to provide career and technical education (CTE) professionals with additional insight on how to better meet the individual educational needs of postsecondary automotive technology students, this study sought to examine their preferences for learning. While it might appear logical to classify auto-tech students as primarily hands-on-learners, the results for research question one suggested that the sample was a diverse group of learners with specific educational preferences (see Figure 2). More specifically, the Learning Style Inventory (LSI) revealed that all learning styles were represented within the sample with the Accommodating style most highly represented (39.8%), and the Assimilating classification the least (16.5%), thus indirectly resembling the diversity of learning style classifications by educational specialization within the LSI technical manual (i.e., Table 1).

Given that the sample of participants statistically represents the population with 95% confidence at the $p<.05$ level, and since all four learning styles were collectively represented by the sample, postsecondary automotive technology faculty within central Pennsylvania should guard against disproportionately teaching to one learning style over another. Even when an association between the students' learning styles and the status of automotive technology work experience since age 16 was revealed, all learning styles were represented by the sample. This is particularly important since past research has shown that educators tend to teach the way they were taught (Gardner, 1999), and the sample of postsecondary automotive technology students was identified as a diverse group of learners. Thus, a process of adopting and adapting instructional techniques and strategies for all learning styles seems most appropriate and is recommended by the authors as it has the ability to enhance the educational experience for the student learner.

This process of adopting and adapting instructional techniques and activities can vary greatly depending on the area of educational specialization. Sample auto-tech activities, as well as the role of instructor, are shown for each of Kolb's learning styles in Figure 3 to assist automotive technology faculty with enhancing the learning environment for which they are responsible.

Accommodating **(Instructor's Role:** Open-ended vehicle problems Student presentations Hands-on repair simulations	**Diverging** **(Instructor's Role:** Class discussions Group lab projects Field trips
Converging **(Instructor's Role: Coach)** Vehicle computer simulations Individual lab assignments Field trips	**Assimilating** **(Instructor's Role: Expert)** Lectures/Presentations Repair manual reading Repair demonstrations

Figure 3. Sample activities and role of the auto-tech faculty for Kolb's learning styles.

A cautionary note regarding the learning style/preference results of this study; there are no right or wrong classifications, and everyone uses each learning style and preference for learning to some degree. While the results do represent the population with no more than a 5% margin of error with 95% confidence, the findings of this study are limited in a sense because: (a) they are not generalizable outside of the target population; and (b) the instrumentation format was self-reporting in nature and could have been incorrectly reported by participants. Thus, the results should be viewed as a tool to assist in better understanding the population of postsecondary automotive technology students in central Pennsylvania. The results of the LSI identified the strength of preference not the degree of learning style use.

Therefore, type biases and/or negative stereotyping of this student population as a result of the findings within this study should be avoided at all costs.

Recommendations

We now know the learning style distribution of postsecondary automotive technology students in central Pennsylvania. Based on the conclusions of the study, the authors make the following recommendations. First, pre-service automotive technology teachers within central Pennsylvania should be introduced to the practical implications of learning style characteristics within an accredited teacher education program prior to working with students. Second, all first year postsecondary automotive technology students within central Pennsylvania should complete the Learning Style Inventory (LSI) during the first month of the academic year to assist both students and faculty members in identifying characteristics critical within the teaching and learning process. Third, postsecondary automotive technology faculty members within central Pennsylvania should implement an educational system of adopting and adapting instructional strategies and activities that naturally align with their students' learning style preference/characteristics identified from the completed LSI assessments. Fourth, since the CTE discipline has never been analyzed or reported, the distribution of postsecondary automotive technology learning styles within Table 3 should be placed in the learning style by educational specialization section of the LSI technical manual (i.e., Table 1). Finally, since there is a dearth of learning style studies within the trade and industry sector of career and technical education, this study should be replicated in specializations such automotive collision repair, building trades, welding, and precision machining.

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Teacher Challenges to Implement Engineering Design in Secondary Technology Education (Third article in 3-part series)

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Abstract

This descriptive study examined the current status of technology education teacher practices with respect to engineering design. This article is the third article in a three-part series presenting the results of this study. The first article in the series titled *Examination of Engineering Design Curriculum Content* highlighted the research findings regarding engineering design curriculum content delivered by technology education teachers. The second article in the series titled *Examination of Assessment Practices for Engineering Design Projects in Secondary Technology Education* reported technology education teachers' assessment practices when implementing engineering design projects in the classroom. The sample for this study was drawn from the current International Technology Education Association (ITEA) membership database. This article will present the research findings that identified challenges faced by technology educators when seeking to implement engineering design.

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Introduction

There are a growing number of leaders in technology education who are encouraging the implementation of a new focus for technology education: a focus on infusing engineering design concepts into technology education (Daugherty, 2005; Hill, 2006; Wicklein, 2006). Simultaneously, curriculum programs such as *Project Lead The Way*, *Engineering by Design*, and *Project ProBase* have provided new curriculum options for technology education teachers to infuse engineering concepts into technology classrooms (Rogers, 2005; Dearing & Daugherty, 2004). Some states have taken great strides to assist the field of technology education move towards an engineering focused curriculum. Administrators within the Departments of Education in Georgia have been working to assist technology education teachers to move their curricular efforts to an engineering design focus (Kelley, Denson, & Wicklein, 2007). Educators in the state of Massachusetts have even adopted curriculum standards that place specific emphasis on the infusion of engineering concepts into the technology education curriculum (Massachusetts Department of Education, 2001). In 2004, the State of Maryland also adopted new standards in technology education to include engineering concepts, and similar efforts have taken place in the State of New Jersey (Ross & Bayles, 2007). Although these are trends that suggest the field of technology education is on the move, the field's history of resisting change may be a cause for concern to the question of, is real change taking place in actual teacher practice (Clark, 1989; Sanders, 2001)? In addition, questions arise about what hurdles, barriers, and challenges are preventing successful curriculum changes from taking place related to an engineering design focus for technology education? It is an appropriate time to investigate what challenges are facing technology education teachers as they seek to infuse engineering design into technology education. This article is derived from results from a larger status study related to engineering design in technology education. The research question that will guide this study is; what selected challenges and barriers are identified by secondary technology educators when teaching engineering design in technology education?

Related Literature

Identifying barriers standing in the way of successfully infusing engineering design and pre-engineering into K-12 classrooms has been investigated by a number of researchers (Shields, 2007; Yasar, Baker, Robinson-Kurpius, Krause, & Roberts, 2006). Shields (2007) investigated barriers to implementing Project Lead The Way (PLTW) programs as perceived by Indiana high school principals and identified the *cost of implementing PLTW* as a significant obstacle (M 3.6 SD 0.91 on a 5-Likert scale).

Yasar, et al. (2006) developed an instrument to assess K-12 teachers' perceptions of engineers, and familiarity with teaching Design, Engineering, and Technology (DET). They conducted research with 98 K-12 teachers in the State of Arizona and identified ten items as perceived barriers to teaching DET. *Time* and *administrative support* were identified as barriers to infuse DET into the curriculum. Furthermore, participants who were identified as being unfamiliar with DET also indicated that they lacked confidence in their abilities to teach DET. Others have also identified that K-12 teachers lack confidence in their abilities to teach design and engineering and as a result shy away from implementing engineering concept into the classroom (Brophy, Klein, Portsmore, & Rogers, 2008; Creighton, 2002).

Focus groups participating in a leadership workshop on K-12 Engineering Outreach held by the American Society of Engineering Education (ASEE) in 2004 with over 150 educators in attendance identified the lack of state standards as a major constraint to promoting engineering education at the K-12 level (Douglas, Iversen, & Kalyandurg, 2004). This observation of a lack of standards was stated even though the States of Maryland, Massachusetts, and New Jersey have developed engineering content standards, providing state support for teaching engineering concepts in K-12 classrooms (Ross & Bayles, 2007).

Recently several program initiatives have been created to provide professional development experiences for technology education teachers to assist in infusing engineering design concepts into the classroom (Burghardt &Hacker, 2007; Burke & Meade, 2007; DeMiranda, Troxell, Siller, & Iversen, 2008; Ross & Bayles, 2007). As a result of these professional development experiences, a number of challenges facing technology teachers as they seek to make these curricular changes have been identified. One such project that aids a teacher in the area of engineering education is INSPIRES Curriculum (INcrease Student Participation, Interest and Recruitment in Engineering and Science). Funded by the National Science Foundation (NSF) this project is designed to provide professional development and engineering focused curriculum for technology education teachers (Ross & Bayles, 2007). During the INSPIRES professional development workshops, technology education teachers (N=17) indicated that although the teachers acknowledge the importance of making connections between science and engineering (63% strongly agree), only 31% of the technology teachers surveyed indicated they were strongly prepared to do so. Only 25% of the technology teachers attending the INSPIRES workshop indicated that they provide instruction to make connection between science and engineering. Ross and Bayles (2007) indicated they discovered through follow-up classroom observations that technology education teachers tended to minimize the mathematical and simulation portions of the INSPIRES curriculum, instead, rushing students to build projects. Furthermore, the researchers rarely witnessed technology education teachers explicitly discussing the science and mathematical concepts embedded in the design challenges with students. Sanders (2008) indicated that technology education teachers are rarely known to explicitly identify science or mathematical concepts as student learning outcomes embedded within a lesson or learning activity.

Gattie & Wicklein (2007) investigated perceptions of ITEA members towards curricular value of the infusion of engineering design. This research sought to identify the instructional needs of high school technology educators regarding engineering design instruction. Over 90% of the in-service teachers indicated that engineering design was an appropriate focus for their instructional program. However, the teachers in this sample also indicated some strong needs to properly infuse engineering design in technology education. Several notable needs identified were that 93% of the teachers indicated the need to learn how to integrate the appropriate levels of mathematics and science into instructional content and 87% indicated the need to develop additional analytical (mathematics) skills (Gattie & Wicklein , 2007). The instrument included a total of thirteen identified instructional needs to teach engineering design.

Although this review of literature reveals research studies that have identified challenges, barriers, and constraints to the infusion of engineering concepts or engineering design into the classroom, most of these studies have not focused on secondary technology educators. For example, Shields (2007) surveyed Indiana principals; likewise, Yasar, Baker, Robinson-

Kurpius, Krause, and Roberts (2006) surveyed Arizona K-12 educators. Clearly, a study is necessary to identify the most common challenges facing technology education teachers across the nation as they seek to infuse engineering design into secondary classrooms and to further extend the results of the Gattie and Wicklein's (2007) study.

Methodology

This descriptive study drew a full sample of high school technology teachers from the current International Technology Education Association (ITEA) membership list. The sample consisted of all high school technology teachers regardless of whether they indicated they were teaching engineering design in their classroom. The identified population of this study consisted of a total of (N) 1043 high school technology education teachers in the ITEA membership database as of September 11, 2007. Using the Krejcie and Morgan (1970) method to locate sample size for a given population, the required sample size was set at 285 (Gay & Airasin, 2000). The original research design for this study called for an increase of the initial mailing of the survey by 48.1 percent, the average success rate of an initial mailing (Gall, Gall, & Borg, 2007). However, close communication with ITEA personnel revealed that ITEA survey mailings typically yield a 20-25% rate of return (Price, personal communication). The researcher determined that a full sample mailing to all ITEA high school members was necessary to achieve the desired sample of 285.

An invitation message was sent electronically through e-mail to all ITEA members in the sample, explained specific instructions for completing the on-line questionnaire and directed participants to access a specific website to obtain and complete the survey questionnaire. The on-line questionnaire was developed using the guidelines and recommendations outlined by Dillman, Tortora, and Bowker (1999). There was a request to return the survey on a specified date.

The researchers sent out the surveys to the entire sample group of 1043 high school teachers. After waiting three days past the specified date of return which was three weeks after the initial mailing, the researcher contacted non-respondents by sending a follow-up e-mail delivered letter containing the URL for the on-line survey link. This has been a proven method used by other researchers to achieve compliance from non-respondents (Gall et al., 2007).

Results

Teacher challenges were identified as barriers, problems, or issues that often occur for technology educators as they seek to make curriculum changes towards engineering design as a focus and could possibly impede their ability to successfully implement necessary changes. The teacher challenges section of the survey instrument asked participants to rate their level of experience with fourteen selected teacher challenges using a five point Likert-type scale (0 = Never, 1 = Rarely, 2 = Sometimes, 3 =Very Often, and 4 = Always). The fourteen selected teacher challenges were adapted from the Gattie and Wicklein (2007) study that also sought to identify the most commonly experienced of the identified challenges. The highest rated challenges were *integrating the appropriate levels of mathematics and science into instructional content* (mean of 2.49), *locating appropriate laboratory equipment to teach engineering design* (mean of 2.40), and *acquiring funding to purchase tools and equipment to teach engineering design* (mean of 2.31). Complete results of the teacher challenges for infusing engineering design into the technology education curriculum are presented in Table 1. Although these items yielded the highest mean scores, these results were below the mid-point for a 5-point Likert scale with mean scores falling between 2 = Sometimes and 3 =Very Often. It can be concluded that these mean scores falling between 2 and 3 indicate that the average response for those who were participating in this study do experience these challenges, just not to a level 3 or *Very Often*. These results must be viewed in light of the fact that the results did not receive high mean scores (over means of 3). However, the higher mean scoring teacher challenge items in this study were similar in wording to teacher challenges that have been identified in other studies (Gattie & Wicklein, 2007; Ross & Bayles, 2007).

Table 1. Teacher Challenges Infusing Engineering

Teacher Challenges	*M*	SD
integrating the appropriate levels of mathematics and science into instructional content	2.49	0.88
locating and learning the appropriate levels of mathematics and science to teach engineering design	2.27	0.93
locating and learning knowledge of engineering fundamentals (statics, fluid mechanics, dynamics)	2.10	0.97
locating appropriate textbooks to teach engineering design	2.14	1.08
locating the appropriate laboratory equipment to teach engineering design	2.40	1.10
locating the appropriate laboratory layout and space to teach engineering design	2.18	1.17
acquiring funding to purchase tools and equipment to teach engineering design	2.31	1.23
acquiring funding to purchase materials to teach engineering design	2.25	1.21
networking with practicing engineers for consultation	2.04	1.15
obtaining support from mathematics and science faculty	1.96	1.08
obtaining support from school administration and school counselors	2.11	1.16
obtaining support to promote engineering design course by school administration	1.94	1.22
obtaining community support to implement engineering design courses	1.73	1.09
obtaining parent support to implement engineering design course	1.73	1.08

Design

The survey also contained one open-ended response question, allowing participants to identify any additional challenges they face that impedes them from infusing engineering design into technology education. These additional challenges were summarized and categorized into common themes. A careful review of these individually identified teacher challenges revealed that many respondents took the opportunity of the open-ended response question to further emphasize some of the previously identified challenges in the survey. The top challenges that were emphasized were (1) *lack of funding -acquiring funding to purchase tools and equipment to teach engineering design* (frequency of 14), and (2) *lack of support- from administration, guidance, mathematics and science faculty, community, or state education department* (frequency of 11); *a lack of clear and concise curriculum that is unrestricting and contains a proper blend of technical skills and knowledge* (frequency of 11); *a fear of enrollment loss of students due to lack of interest in engineering, low academic ability, and or motivation to take engineering courses* (frequency of 11). Other top teacher challenges that were identified by respondents was *a lack of time for professional development and teacher prep time* (frequency of 9). See Table 2 for a complete review of the additional teacher challenges identified by responders in the open-ended response question.

Table 2. Additional Teacher Challenges Identified by Participants (Open Ended Response)

Teacher Challenge	*f*
Money - lack of funds to purchase state of the art equipment, budget cuts, changes are costly	14
Curriculum Lack of clear and concise, unrestricting, appropriate blend of skill and knowledge	11
Support -lack of support from administration (3), guidance(1) mathematics and science teachers(1) community (2) State Education Dept (4)	11
Enrollment - fear of loss of students due to lack of interest, academic ability, motivation	11
Time - lack of time for professional development, teacher prep time, etc	9
Equipment and Software - lack of needed equipment, tools, and software	8
Student Schedule -lack of room in student schedule for electives due to graduation requirements	7
Teacher Knowledge - lack of teacher knowledge about engineering design content	3
Lab Space	3

Conclusions

The results of this study confirm discoveries found in subsequent research related to the engineering design curriculum content and assessment practices used by technology teachers to teach engineering design at the high school level. The teacher challenge results found respondents indicating difficulties in locating and integrating appropriate levels of mathematics and science for engineering design. Technology teachers participating in this study indicated that *integrating the appropriate levels of mathematics and science to teach into instructional content* was often a challenge (mean 2.48; SD 0.88). The fourth highest mean score item was similar in context *locating and learning the appropriate level of mathematics and science to teach engineering design* (mean 2.27; SD 0.93). Other high mean scoring challenges were in *locating and acquiring appropriate tools and equipment to teach engineering design effectively*. The second highest identified challenge was *locating the appropriate laboratory equipment to teach engineering design* (mean 2.40; SD 1.10). The third highest mean scoring individual item was *acquiring funding to purchase tools and equipment to teach engineering design* (mean of 2.31; SD 1.23). Locating appropriate funding to acquire proper tools and equipment has often been identified as a top challenge for technology education teachers (Wicklein, 1993, 2005). It is also logical that technology teachers are identifying challenges in locating the appropriate laboratory equipment and acquiring the proper funds to purchase such equipment. Similarly, in a study of the status of engineering design in Georgia’s technology education programs, Denson, Kelley, and Wicklein (2009) found that over 88.0 % of Georgia’s technology education teachers identified a need to locate and acquire appropriate types of tools and test equipment to teach engineering design (mean of 3.20; SD 1.12). These results indicate that technology education teachers are often struggling to locate appropriate tools and equipment to teach engineering design in technology education. Moreover, there is little evidence in literature to suggest that anyone in the field of technology education has properly described the appropriate equipment to teach engineering design within technology education. The fact that appropriate tools and testing equipment have not currently been identified spurred the Engineering and Technology Education Advisory Committee for Georgia Department of Education to recommend that a subcommittee be formed of technology education teachers, university professors, and school administrators in the state of Georgia to investigate and identify appropriate tools and test equipment that will assist technology teachers to teach engineering design in middle and high school technology education programs (Advisory Committee on Engineering and Technology Education in Georgia, 2008).

The participants in this study provide some indication why mathematics is not emphasized in technology education curriculum when they indicated that *integrating the appropriate levels of mathematics and science to teach into instructional content* (mean 2.48; SD 0.88) and *locating and learning the appropriate level of mathematics and science to teach engineering design* (mean 2.27; SD 0.93) were often challenges to successfully teach engineering design. These results indicate the need for developing additional professional development opportunities to assist technology educators to properly infuse engineering design into technology education curriculum. It is important to note that the debate is very much alive about what are the appropriate levels of mathematics and engineering science for teaching engineering design at the secondary level, more research is needed to determine what these appropriate levels would entail.

Implications for Professional Development

The results of this study provides an excellent opportunity for leaders in the state of Georgia, and any other state seeking to design professional development, to be informed about the teaching practice, assessment strategies, and identified challenges of current technology education teachers seeking to implement engineering design curriculum. These results have identified teacher challenges faced when seeking to implement an engineering design focused technology education program. Information obtained from this research can help professional developers create workshops, curriculum, and support materials that will properly address teacher concerns and equip these educators with the necessary skills and knowledge to properly infuse engineering design into the classroom. Upon review of Table 1, the top three mean scores identified teacher challenges that can be addressed through teacher professional development and are necessary to overcome for technology education teachers to have the capacity to successfully infuse engineering design into the classroom. Professional development programs should be focused, consistent, and relevant to engineering design content while at the same time address these teacher challenges identified in this study.

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A CROSS-CASE ANALYSIS OF GENDER ISSUES IN DESKTOP VIRTUAL REALITY LEARNING ENVIRONMENTS

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Abstract

This study examined gender-related issues in using new desktop virtual reality (VR) technology as a learning tool in career and technical education (CTE). Using relevant literature, theory, and cross-case analysis of data and findings, the study compared and analyzed the outcomes of two recent studies conducted by a research team at Oklahoma State University that addressed gender issues in VR-based training. This cross-case analysis synthesized the results of these two studies to draw conclusions and implications for CTE educators that may assist in developing or implementing successful virtual learning environments for occupational

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training. The cross-study findings suggested that males and females may be differently affected by VR and that females may be less comfortable, confident, and capable in virtual learning environments, particularly when the environments are highly technical and visually complex. The findings indicate caution in the use of VR in mixed-gender CTE programs, particularly in programs that are heavily female-gendered.

Introduction to Desktop Virtual Reality

To maximize their instructional effectiveness, career and technical education (CTE) programs need to apply effective learning tools in their classrooms and laboratories. Recent literature reviews of published research (c.f., Ausburn & Ausburn, 2004, 2008a, 2008b; Ausburn, Ausburn, Cooper, Kroutter, & Sammons, 2007; Ausburn, Ausburn, Ashton, Braithwaite, Dotterer, Elliott, Fries, Hermes, Reneau, Siling, & Williams, 2006) have consistently documented the effectiveness of virtual reality (VR) as a learning tool in a variety of settings. The research has shown that many educational institutions, industries, and organizations are now turning to VR to provide effective and cost-efficient ways of teaching and career preparation and development. The field most actively reported in the VR literature is medical/dental, where large numbers of published studies have attested to VR's benefits (Harb, Adams, Dominguez, Smith, & Randall, 2005; Imber, Shapira, Gordon, Judes, & Mitzgar, 2003; Jaffe & Brown, 2000; Jeffries, Woolf, & Linde, 2003; Mantovani, Gaggiolo, Castelnuovo, & Riva, 2003; Moorthy, Smith, Brown, Bann, & Darzi, 2003; Patel, Gallagher, Nicholson, & Cates, 2004; Riva, 2003; Seymour, Gallagher, Rorr, O'Brien, Bansal, & Anderson, 2002; Urbankova & Lichtenthal, 2002; Wilhelm, Ogan, Roehaborn, Caddedder, & Pearle, 2002).

Engineering has also reported considerable success with virtual reality instruction (Sulbaran & Baker, 2000).

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

Despite issues with costs, technology concerns, and instructional design challenges with VR, Watson's (2000) conclusion that "Most would consider that … [VR] systems provide strong potential … for the educational process," (p. 231) appears to represent well the current general position and expectation of virtual reality researchers and users.

The term *virtual reality (VR)* has undergone continuous changes since its introduction in the late 1960s as immersive experiences with computer-generated imagery via head-mounted displays (HMDs). According to Loftin, Chen, and Rosenblum (2005), VR is a set of "… integrated technologies that provide multimodal display of and interaction with information in real time, enabling a user… to occupy, navigate, and manipulate a computer-generated environment" (p. 479). Davies (2004) defined VR as a "… technique of using computers to model real … environments in a three dimensional space that allows people to interact with the environment in a fashion that is both natural and intuitive" (p. 3). Ausburn, Martens, Dotterer, and Calhoun (2009) viewed VR as simulation of locations that model for users the characteristics of the locations and allow them to "visit" and "… experience simulated locations with as much fidelity as possible" (p. 1). Di Blas and Poggi (2007) also emphasized the importance of "presence" in VR, which they identified as engendering in users a sense that they have actually *been* somewhere rather than just *seeing* it. In summary, virtual reality (VR) currently refers to a variety of computer-based experiences ranging from fully immersive environments with complex HMD gear and body suits, to realistic PC-based imagery environments. However, in all its forms, VR is basically a way of simulating or replicating a 3D environment through computer-generated imagery and giving the user a powerful sense of "being there," taking control, and actively interacting with the environment and its contents (Ausburn & Ausburn, 2004, 2008b; Ausburn, Martens, Dotterer, & Calhoun, 2009; Beier, 2004; Brown, 2001).

The newest form of VR is called *non-immersive or desktop VR.* It uses QuickTime, Java, or Flash technology to present high-resolution panoramic imagery on a standard desktop computer. Desktop VR "movies" are created by taking a series of digital still photographic images and then using special VR software to "stitch and blend" the images into a single panoramic scene that the user can "enter" and explore individually and interactively. The user employs a mouse to move and explore within an on-screen virtual environment as if actually moving within a place in the real world. Movements can include rotating the panorama image to simulate physical movements of the body and head, and zooming in and out to simulate movements toward and away from objects or parts of the scene. Embedded individual virtual objects can be "picked up," rotated, and examined as the user chooses, and clickable "hot spots" can also be used to navigate at will (Ausburn & Ausburn, 2008b; Ausburn, Ausburn, Cooper, Kroutter, & Sammons, 2007). What characterizes these desktop VR movies and distinguishes them from traditional video is that *the user* chooses where, when, and how to move, explore, and examine rather than being controlled by the prior production decisions of a videographer (Ausburn & Ausburn, 2004).

What is important about the recent major technical advances in desktop VR for CTE educators is that these technologies now bring the advantages of VR experiences within the fiscal and technical capabilities of most schools and instructors. Because of the recent dramatic improvements in the technical capabilities and features of desktop VR and its accessibility to schools, teachers, and organizations, this technology is emerging as an important new tool for CTE. The new desktop VR is the focus of the research and findings reported in this paper.

Gender and Virtual Environments: Theoretical/Conceptual Framework and Supporting Literature

While VR has repeatedly demonstrated positive learning outcomes, some research has also shown that this effectiveness has not been identical across genders. This research is especially relevant to educational settings that involve training for occupations that are highly gendered, such as the health and medical fields. Educators who use virtual reality in training for gendered occupations need to be cognizant of gender-related issues associated with virtual reality in order to effectively use this new technology. Research has identified several theoretical and conceptual areas that suggest reasons for differential effects of virtual environments across genders. These include visual/spatial functioning, human navigation and wayfinding theory, and socially- and culturally-influenced perceptions of and experiences with computer technology. These factors come together in self-efficacy theory, as each influences the formation of an individual's technological self-efficacy, which determines an individual's performance and perception of that performance in a technology learning environment such as VR. These variables and concepts and their proposed relationships allowed the researchers to form a working theoretical and conceptual framework for the research reported in this study. This theoretical/conceptual framework is shown in Figure 1. This framework and its supporting literature are discussed below.

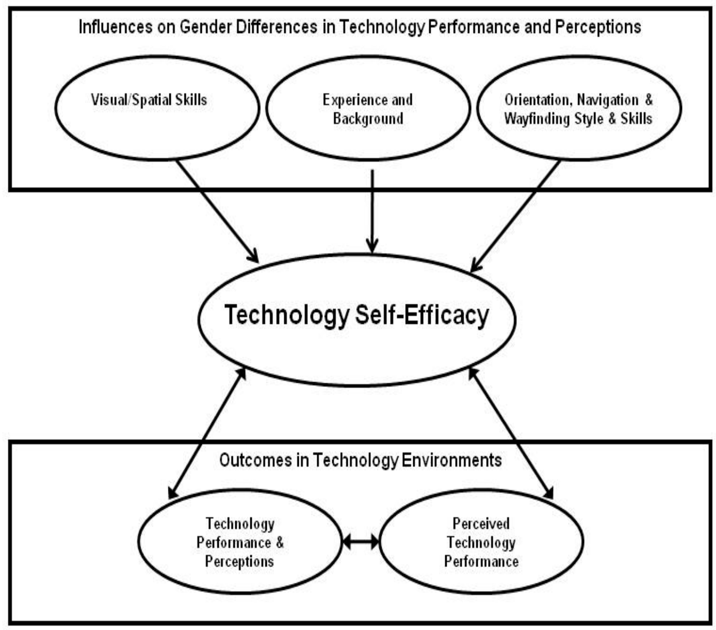

Figure 1. Theoretical/conceptual framework for this study. This proposed framework for gender effects in technology-based learning environments applies specifically to virtual reality environments in the context of this study.

In the area of *visual-spatial functioning*, half a century of research history with paper-and-pencil and performance tests such as the *Differential Aptitude Tests* (Bennett, Seashore, & Wesman, 1973), the *Cards Rotation Test*, (Allen, 1974), the *Generic Mental Rotation Test* (Hakstian & Cattell, 1975), the *Primary Mental Abilities- Spatial Relations Test*, *(*Keyes,

1983) and the Guilford-Zimmerman (1948) test of spatial orientation have revealed consistent gender differences in skill in mental rotation/manipulation of objects and spatial orientation, with females generally having lower skill and greater difficulty than males in these cognitive tasks. Numerous studies have documented this gender discrepancy. For example, Linn and Peterson (1985) and Voyer, Voyer, and Bryden (1995) both reported higher performance levels by males on mental rotation and spatial visualization tests. Terlecki and Newcombe (2005) claimed that facilitation of computer experience through training may have differential effects on men's and women's spatial performance, and reported that men not only perform at higher levels than women on tests of spatial and mental rotation ability, but also tend to have more spatial experiences. Research evidence has also suggested that the long-observed gender gap in mental rotational skills is exaggerated in virtual environments, and that men and women perceive virtual experiences quite differently, with men preferring more interactive environments than women (Space, 2001; University of Washington, 2001). Further, Waller, Knapp, and Hunt (1999) asserted that (a) understanding the spatial characteristics of virtual environments may be more challenging for women than for men, (b) in general, tests of mental visual manipulation and spatial orientation – in which females have typically been less skilled than males – are highly predictive of the ability to acquire accurate spatial information in a virtual environment, (c) gender-related differences in proficiency with a VR navigational interface are particularly important in determining ability to acquire spatial information, and (d) individual differences related to gender and cognitive ability account for more variance in performance on tasks requiring spatial knowledge acquisition from virtual environments than does the actual visual fidelity of the VR representation of the physical world. Waller (2000) subsequently agreed with that position and reported that spatial ability and interface proficiency – both of which had been statistically related to gender – had the strongest effects in spatial knowledge acquisition in virtual environments. He concurred with the earlier conclusion by Hunt and Waller (1999) that:

> Our results suggest that there are very strong male-female differences in the ability to benefit from VE [Virtual Environment] training. Recent work in our lab has suggested that most of the effect of gender in VR spatial learning is statistically associated with differences in spatial ability … and proficiency with the navigational interface. (p. 69)

Regarding the alterability of these two predictors of success in training with virtual environments, Hunt and Waller (1999) stated clearly their belief that "… there is surprisingly little evidence that gender differences in psychometrically-assessed spatial ability can be reduced by training" (p. 69). However, both Hunt and Waller (1999) and then Waller individually (2000) theorized that females' functioning in virtual environments and their ability to benefit from VR training could be improved, and the gender differences reduced or even eliminated, through appropriate training to increase women's proficiency with the VR user interface.

Several studies by Waller and his associates have specifically documented the existence of gender-related performance differences in virtual environments. Waller (2000) asserted that in his studies women who used desktop VR were statistically less likely to derive accurate spatial information from it than men, and that gender was one of the most powerful predictors of spatial knowledge transfer in virtual environments. Similarly, other studies of training in virtual environments have reported gender differences in favor of males on a variety of performance measures (Waller, Hunt, & Knapp, 1998a, 1998b; Waller, Knapp, & Hunt, 1999).

One possible explanation of at least part of observed male advantage in acquiring and using spatial configurational information in complex environments has been proposed by both Hunt and Waller (1999) and by Lawton (1994; Lawton, Charleston, & Zieles, 1996). The explanation proposed by these researchers is based in *human wayfinding and navigation theory*. This body of theory addresses how individuals know where they are in an environment, where important objects are in relation to them and to each other, and how to move from place to place. The proposed rationale for male advantage in spatial wayfinding is that it can be at least partially attributed to gender differences in specific strategies used during the "wayfinding" process. They proposed that males tend to use wayfinding strategies appropriate for navigation (e.g. bearing to landmarks), while females concentrate on strategies more suitable to tracking and piloting (e.g. describing control points and route cues such as street signs).

Several researchers have taken quite different theoretical directions for discussing gender differences in performance in virtual environments. One approach has been to examine male/female differences in *technology self-efficacy*. Bandura's well known theory (1994, 1997) defines the self-efficacy construct as belief or confidence in one's ability to take appropriate actions to successfully perform a certain task. Bandura also asserted that one's level of self-efficacy, regardless of its truth, could impact actual performance. Some researchers have discussed technology self-efficacy and identified it as an important factor in successfully using electronic technology (e.g. Eastin & La Rose, 2000; Kandies & Stern, 1999).

This notion of technology self-efficacy raises the possibility that gender differences in success with learning from and in virtual environments may be related to different experiences and perceptions of digital technologies. The technology literature of the 1980s – 2000 period presented many studies showing that attitudes toward technology differed significantly between males and females, reporting that males had greater interest in and knowledge of technology, and that females perceived technology as more difficult and less interesting. Typical of the period were studies by Temple and Lips (1989) that found males generally reported more comfort and confidence with computers, and by Waller, Knapp, and Hunt (1999) that found gender-related differences in prior computer use accounted for considerable variance in performance on tasks requiring gaining spatial knowledge from VR. Also abundant over the last 15 years have been studies documenting female "technophobia" and computer anxiety (e.g. Gilbert, Lee-Kelley, & Barton, 2003; Rainer, Laosethakul, & Astone, 2003; Schumacher & Morahan-Martin, 2001; Todman & Day, 2006; Weil & Rossen, 1995; Whitley Jr., 1996). The American Association of University Women (AAUW) (2000) conducted extensive research examining the technology gap between girls and boys and concluded that teacher attitudes, public media, software manufacturers, and curriculum all had detrimental effects on gender technology self-efficacy deficits and lowered self-confidence of young girls about technology.

Bain and Rice (2006-2007) recently reviewed the body of literature on gender and technology and then addressed the question of whether gender differences in perception and use of technology still existed. They found that the majority of females in their study did not perceive computers as being difficult and were using them more than in the past, but did not have the same level of confidence or technology self-efficacy as their male peers. In another recent study, Hogan (2006) documented the persistence of higher levels of technophobia among older women and men in Ireland, suggesting this persistence may not be confined to the United States.

Research has frequently identified gender as a strong predictor of technological self- efficacy, with females more likely to rate self-perception of their computer skills lower than males (Bain & Rice, 2006-2007; Busch, 1995; Hargittai & Shafer, 2006; Hogan, 2006; Temple & Lips, 1989). Women have also frequently reported less confidence and more anxiety with usage of spatially-related materials and computer software (Terlecki & Newcombe, 2005).

It would thus appear from the research evidence that despite gains in their positive perceptions and usage of computers, females may still lag behind males in technology self-efficacy, which may continue to impact their performance in high-technology learning environments such as VR.

Several reasons have been proposed for gender differences in technology self-efficacy. These have included (a) the spatial ability differences discussed by Waller and his associates, (b) differences in interest and experience with video games and related technologies such as VR (Philips, Rolls, Rouse, & Griffiths, 1995), (c) psycho-social gender differences in preferences related to functions and features of games (Heeter, Chu, Mishra, Egidio, & Lee, 2005; Heeter, Mishra, Egidio, & Wolf, 2005; Heeter & Winn, 2005; Heeter, Winn, Egidio, Mishra, & Lownds, 2003; Heeter, Winn, & Greene, 2005), and (d) a general "masculinization" of computer gaming and related technologies. For example, Graner (2004) asserted that males are encouraged to gain pleasure from aggressive behavior and competitive play of violent games while females, because of their historically more nurturing care-giving roles, are less comfortable with aggressive competitive violence in gaming. Oldenziel (1999) contended that technology as a masculine domain is a socially constructed concept which has been historically used to define masculine/feminine roles. The AAUW (2000) study cited above echoed this contention that the "computer culture has become linked to a characteristically masculine worldview" (p. 16) which forces girls and women to make decisions whether to embrace technology or opt for culturally accepted views of themselves as feminine. Gannon (2007) asserted that the language, images, and concepts used to mass-market various forms of technologies to either women or men perpetuate cultural stereotypes of the nature of technology. Similarly, Heeter, Chu, Mishra, Egidio, and Lee (2005) supported the existence of gender differences and cultural stereotyping in gaming preferences. They found that boys liked game features such as weapons, fighting, challenging levels, complex controls, and navigating sharply through the game space using teleporting or warps; while girls liked game features such as story lines, multiple levels to accommodate varying skill levels, adequate instructions, collaboration and chat, and on-screen avatars representing females and appealing pets. The notion of gaming masculination was supported by Hess and Niura (1985). Their study found a significant amount of the computer videogame genre to be focused towards typically "masculine" interests, with emphasis on aggression or violence. This led them to conclude that because of this gender bias, females may be less likely to engage in spatially- related computer activities such as gaming.

The relationships among the variables impacting the gender differences observed in research on learning technology have been well documented over more than two decades in the reported literature in educational technology, computing and information sciences, cognitive sciences, and sociology. This research history was synthesized by Cooper (2006) in an extensive review of 20 years of digital divide literature based on gender. In a psychological analysis of these variables, Cooper contended that the gender digital divide in technology self-efficacy and performance is fundamentally a problem of computer anxiety rooted in gender socialization interacting with stereotype of computers as toys for boys. For Cooper, this anxiety leads to, and manifests itself in, the differences in computer attitudes and performances that are frequently observed and reported in cross-gender computer studies (2006).

Virtual Reality Studies at Oklahoma State University

As desktop virtual reality began to improve technically and to offer CTE programs and instructors a cost-effective way to bring the benefits of virtual learning environments into educational settings, a research team at Oklahoma State University (OSU) launched a line of inquiry into this dramatic new technology. Prior to the OSU research, published VR studies had focused primarily on complex immersive VR technologies rather than on the more accessible new desktop alternatives (Ausburn & Ausburn, 2004, 2008b), and the few studies that did test desktop VR (e.g. Jeffries, Woolf, & Linde, 2003; LaPoint & Roberts, 2000; McConnas, MacKay, & Pivik, 2002; Scavuzzo & Towbin, 1997; Seth & Smith, 2002) were not focused on potential gender issues with emerging virtual technology.

The desktop VR studies at OSU have taken a different approach from the anthropology or descriptive case study methodology that Moore and Kearsley (2005) contended has often defined and limited the usefulness of research on new technologies. Instead, the OSU studies have been quasi-experimental in design and grounded in both classic and contemporary instructional design theories such as media supplantation capabilities (Ausburn & Ausburn, 1978, 2003; Salomon, 1970, 1972), media concreteness theory (Dale, 1954), cognitive load theory (Sweller, 1988; Sweller, 1999; Sweller & Chandler, 1994), self-efficacy theory (Bandura, 1994, 1997), individual differences theories, and Aptitude-Treatment Interaction theory (Cronbach & Snow, 1977). Ausburn and Ausburn (2008a) summarized the research model for the OSU studies in their recent review of the research series:

> They have focused on applications of desktop VR in technical education and have had … samples of technical and occupational students and educators as participating subjects. All the OSU studies have used random assignment of subjects to treatment groups and post-test-only research designs. All data have been collected in technical education institutions by trained members of the VR research team using standardized protocols to ensure uniform data collection procedures. The sample sizes have been small, and the studies have been considered to be pilot studies that will point the way to larger studies in the future. (p. 53)

Two of the empirical studies in this series by the OSU VR research team specifically addressed gender issues in desktop VR environments. These studies are summarized below as data sources or *cases* for the cross-case analysis presented in this paper.

Purpose and Methodology of the Present Study

The two previously-published OSU studies were chosen for this analysis because they were believed to be both “instrumental” and “collective,” as defined by Stake (2003) in his analysis of case study research. According to Stake, an *instrumental* case study is examined to provide insight into an issue or to re-examine a generalization. An instrumental case study serves to facilitate the researcher’s interest and promote understanding in something else other than the narrow specifics of the case under study. Stake identified *collective* case study technique as a way to build on an instrumental case by extending it to several cases. In collective case studies, two or more individual cases are selected for study because the researcher believes that examining them together will lead to a better understanding of an even larger collection of cases (2003). The two studies chosen for comparative analysis in the present research has several important similarities. Both addressed (a) the effectiveness of VR as a learning technology, (b) the interaction of gender and VR, and (c) learner outcomes based on both performance and perceptions. Both studies used similar quasi-experimental research designs and similar instrumentation. Comparing the nature of the VEs they presented and the differences in their learner outcomes in a collective instrumental case analysis allowed the researchers to advance understanding of gender differences in VR learning environments and the theoretical foundations of those differences.

The methodology of comparing and synthesizing the two instrumental research cases has been termed *cross-case analysis* (Miles & Huberman, 1994) or *cross-case synthesis* (Yin, 2009). Miles and Huberman (1994) defined cross-case analysis as searching for patterns, similarities, and differences across cases with similar variables and similar outcome measures. Yin (2009) asserted that cross-case synthesis should involve at least two cases and that the selected cases could be conducted as independent studies authored by different researchers or as predesigned parts of a single study. In either situation, each case should be treated as a separate study in the cross-synthesis. The two previous OSU research studies selected as the source cases for the present cross-case analysis of gender in VR environments represent the former situation. The cross-case analysis conducted using the two OSU studies focused on comparing the goals, methodology, instrumentation, VE characteristics, and learner performance outcomes. The two source cases had strong similarities in research goals, instrumentation, and methods, as described below. The nature of the VEs they presented was quite different, as described below. The outcome synthesis for the cross-case comparison focused on (a) identifying key findings across the studies, (b) examining discrepancies in the major findings and their contributing factors, and (c) interpreting the outcomes in terms of relevant theories.

Case/Data Source #1

The purpose of the first OSU source study in which gender was a variable (Ausburn & Ausburn, 2008a, 2008b) was to compare the effectiveness of desktop VR with traditional still color images typically used in textbooks in presenting a *non-technical environment* to learners of both genders and two age groups. This quasi-experimental study addressed three aspects of learning outcome by comparing scores of learners who received a desktop VR presentation of the interior rooms of a house with the scores of learners who received still images of the same scene. The subjects were 80 representative adults drawn from the general population who were stratified by gender and age as follows: 20 males aged 18-35, 20 males aged 36-60, 20 females aged 18-35, and 20 females aged 36-60. A limitation of this study was that no information was collected about the previous computer or VR experience or skill of the subjects and equality of the two experimental groups on these variables could not be verified. However, procedures were used to ensure that equal numbers of subjects from each gender and age group were randomly assigned to receive either desktop VR (e.g. interactive panorama movie with hot spots for navigation) or still imagery (e.g. 8 color photos) presentation of the house rooms. The two presentations were created with the same digital camera using the same lens. Both sets of images contained identical visual information. Both treatments were presented via desktop computer and accessed by action button from inside the same PowerPoint® presentation. Both gave the subjects identical instructions for completing their learning tasks. Each subject was tested individually in a setting of his/her choice.

After receiving their presentations, subjects completed three testing instruments developed by the research team to measure (a) *scenic orientation*, (b) *recall of scenic details,* and (c) *perceived confidence in scenic comprehension.* The scenic orientation variable was operationalized as 15 multiple choice items that required subjects to position or locate themselves mentally within the house scene and identify the location of designated objects in relation to their position, such as “behind you” or “to your right.” This operationalization was based on Hunt and Waller’s (1999) definition of orientation as knowledge of one’s location in an environment relative to other important objects and ability to locate objects relative to each other. Recall of scenic details was operationalized as number of correct and non-duplicative items in the house rooms that could be recalled and listed within one minute. This time was established through field testing as optimal for discriminating good and poor recall. Perceived confidence in scenic comprehension was operationalized as self-reported rating on a five-point Likert-type scale ranging from 1 = absolutely no confidence to 5 = absolute confidence. All instruments were field tested to ensure clarity and readability.

Data obtained from this study were analyzed with 2-way ANOVAs. Complete descriptive data, ANOVAs, and findings were reported by Ausburn and Ausburn (2008b); selected data and findings are reported here to support the cross-case gender analysis that is the focus of the present study. The ANOVA analyses supported the efficacy of desktop VR, which produced significantly better scenic orientation, overall

(M_{VR} = 10.95; $M_{Still = 9.55}$; F = 5.51; df = 1,79; p = .02), detail recall (M_{VR} = 7.08; M_{Still} = 5.35; F = 6.95; df = 1,79; p = *.01)*, and confidence (M_{VR} = *3.63;* M_{Still} = 3.03; F = 8.54; df = 1,79; p = .005) and for both genders and both age groups. According to Green and Salkind's criteria (2005), all effect sizes were moderate (.11 < η^2 > .06) using the eta-squared statistic. Also important in this study were its findings related to gender and VR. Unexpectedly, and in contrast to the hypothesized outcomes based on theory and literature, in this familiar and non-technical scenic environment, the females performed significantly better overall than the males with moderate effect size in both scenic orientation ($M_{Females}$ = 11.18; M_{Males} = 9.33; F = 9.62; df = 1,79; p = .003; η^2 = .11) and recall of details ($M_{Females}$ = 7.13; M_{Males} = 5.30; F = 7.78; df = 1,79; p = .007; η^2 = .09). They also tended to be more confident overall about their understanding of the house scene than the males ($M_{Females}$ = 3.48; M_{Males} = 3.18; F = 2.134; df = 1; p = .15) and to benefit more from the VR presentation than the males on both the orientation ($p_{interaction}$ = *.16)* and confidence ($p_{interaction}$ = .09) variables. Complete descriptive and ANOVA data were presented by Ausburn & Ausburn (2008b).

Case /Data Source #2

The unexpected gender-related results of the first study set the stage for a second study by the OSU team. In this study, gender effects in desktop VR were studied in the context of a highly technical environment in a strongly gendered occupation using a mix-method design. The subjects were 42 post-secondary surgical technology students at a large urban technology center. All testing took place in the technology center in a classroom or computer lab. Because of the gendered nature of the surgical technology occupational program, this sample was heavily gender-weighted, with 36 females (85.7%) and only six males (14.3%). In the quasi-experimental part of the study, students were randomly assigned to receive one of two alternative VR presentations of a set of unfamiliar operating rooms. One VR presentation had only the standard panning and "hot spot" navigation features of desktop VR in which clicking on a "hot" item moved the user to another location or additional views of an item, while the other had an additional visual location and navigation mapping feature to assist users in orienting themselves and locating items relative to themselves. The VR scenes in both presentations were extremely complex visually, with many objects unfamiliar to the students, numerous labels and arrows, and complex navigation tools for moving around and examining objects. This VE was very different from the simple and familiar house environment presented in the first study.

Dependent measures for this study were similar to those for the first source study/case reported above and included a similar multiple-choice test of scenic orientation, number of details correctly recalled in one minute, self-reported confidence on a five-point Likert-type scale, and self-reported perceived task difficulty on a five-point scale (not assessed in the first study). Using five-point Likert-type scales, data were also collected on the subjects' self-reported computer skills, experience with video games, and experience with virtual reality. Level of visualizing skill was also assessed using *Successive Perception Test 1* (SPT1), which is a video-based test that requires subjects to view complex figures behind a moving slot and mentally integrate the pieces to form and identify complete patterns. Using SPT1, subjects were classified as either high- or low-visual based on a median split. The two randomly-assigned treatment groups were similar on these skill and experience variables.

This second study yielded numerous findings, several of which are relevant to the gender issue of interest in the present paper and are reported here for comparison with the findings of the first source study/case. The gender results of this second study in a highly technical and visually complex environment (e.g. operating rooms) rather than a familiar non-technical one (e.g. house) were dramatically different from those of the first study. This time, the findings were very much in line with the theory- and research-driven gender expectations. The quantitative two-way ANOVA data showed that regardless of the presence or absence of the navigation mapping tool, the females scored significantly lower overall than the males with large effect size on the test of scenic orientation ($M_{Females}$ = 15.58; M_{Males}= 20.33; F = 7.02; df = 1,41; p = .01; η^2 = 16). They were also significantly less confident than the males with moderate effect size ($M_{Females}$ = 2.55; M_{Males} = 3.60; F = 4.63; df = 1,37; p = .04; η^2 = .12) and rated the learning tasks as significantly more difficult with large effect size ($M_{Females}$ = 3.24; M_{Males} = 2.20; F = 6.83; df = 1,37; p = .01; η^2 = .17).

Additional qualitative gender-related data were also collected in this second study through interviews with 19 of the 42 participants selected at random from the two genders. Basic qualitative findings were consistent with the quantitative findings of the study. The qualitative data, in the form of interview responses, revealed several findings relevant to the purpose of the present cross-case comparative synthesis. Initial analysis of the qualitative interview data consisted of searching for key words and phrases that suggested either positive or negative feelings about, or experiences with, the VR treatment presentations.

All four males who were interviewed made positive comments about their experience with the VR operating rooms. None reported serious navigation or orientation problems, and all gave generally positive impressions of the VR experience. Their descriptions included terminology such as “cool,” “neat,” “easy to get around,” “easy to guide yourself through,” and “good graphics.”

By contrast, the 15 interviewed females presented a less positive impression of the VR experience. Only six of the 15 gave a positive impression of the VR overall, with an additional two leaving a neutral impression. Seven of the females appeared to feel negatively about the VR, reporting unpleasant feelings ranging from physical discomfort and nausea to confusion and frustration. Two of the females stated clearly that they did not like to learn from computers and preferred hands-on or person-to-person learning. Several of the females’ comments indicated problems with orienting and navigation in the VR and revealed feelings of “confusion,” “uncertainty,” “difficulty,” “frustration,” and “being lost.” While the small number of males available due to the gendering of this occupation is a limitation, the four males who were interviewed did not express any of the negative feelings reported by many of the females.

Several specific quotations from the interviewed female participants about their VR experience serve to illustrate the general feelings and impressions of their comments:

<u>Female age 18</u>
“I like to feel it, touch it, so [the computer] kind of makes me feel a little stressed….”

<u>Female, age 21</u>
“I would learn a whole lot more if I was actually physically in the room.”

<u>Female, age 26</u>
“That was very frustrating.”

Female, age 21
"…it doesn't motivate me at all to look at that, I'm just like…there's no point."

Female, age 26
"I don't care for it….If it was there, I might use it but I…would rather learn by touch or someone [asking] questions…."

Female, age 21
"…it was kind of confusing…a little bit difficult…."

Female, age 21
"I was thinking, 'I got it,' then I looked and all those numbers came up and I feel like I didn't really get it."

Female – young – age not reported
"I got the different operating rooms confused. I don't know why. They're pretty much the same, but I think things were mixed up and that I got stuff jumbled a little bit."

These impressions and statements from the study's subjects were consistent with several informal reports of the researchers who recorded personal observations of confusion, frustration, disengagement, and even annoyance among some of the female participants.

Several comments from the female interviewees indicated they had additional problems related to the VR presentation. Some were not aware of the similarity between computer gaming and VR, stating that they had played some computer games but had never seen virtual reality. Some did not seem to recognize or value their own previous computer experience. For example, one respondent adamantly denied having any previous experience with computer gaming or virtual reality, claiming that she "watched her brothers play online games, but didn't participate." However, during the course of the interview, she revealed that she did play Nintendo 64 games. Another female participant told the interviewer she had no previous experience with virtual reality, but later stated she played many online games. It was clear to the interviewer that this student did not equate the online games in which she actively participated with virtual reality. This was consistent with statements of another female student who stated that she had no previous experience with virtual reality, but when discussing the VR scenes of the surgical operating rooms, compared them to an online tour she took of the college campus the previous year. The interviewer concluded that these females did not have a complete understanding of virtual reality technology and that many of them discounted their previous experience as unimportant and irrelevant.

Cross-Case Outcome Comparison, Conclusions, and Implications: Gender Issues for Desktop Virtual Reality as a Learning Technology in CTE

The two desktop virtual reality studies presented above served as the data sources or cases for a cross-case comparative analysis. The purpose of the cross-case analysis was to determine if the available empirical evidence from these two studies in aggregate supported or refuted theoretical expectations and evidence from the literature of differences in performances and/or perceptions between males and females in virtual environments. The variables, methods, and instrumentation of the two studies were similar; at issue were comparisons of the nature of the VEs presented and differences in their learning outcomes.

Based on evidence in the literature, desktop virtual reality (VR) appears to have well-documented potential as a technology for learning and instruction. It can take learners safely and realistically into unfamiliar environments and give them a sense of immersion and personal control of their exploration and discovery. The two Oklahoma State University (OSU) studies reported here appear to support the efficacy of VR in helping some learners orient in visual environments, recall details of the environments, and feel confident in their understanding of the environment. The results of these studies also suggest that, as documented in other VR research literature, the effectiveness of this technology may not be uniform across genders in all circumstances, and that cautions may be appropriate when using VR with female learners to present technical and visually complex environments, as frequently occur in CTE programs. In the OSU studies, the females did well – in fact, better than the males – in orienting within a VR scene, recalling details in the scene, and feeling confident in their understanding *when the scene depicted virtually was simple and familiar to them.* The house interior scene in which the females performed well with VR presentation was visually simple, contained no labels or other visual identifiers, was familiar and comfortable, and was free of complex navigation requirements. In such an environment, the females appeared to exhibit none of the problematic spatial skills, navigation strategies, or technology self-efficacy often claimed for them in the research literature. From a theoretical and explanatory perspective, it may be that the concreteness, accuracy, and representational fidelity of VR, plus its ability to explicitly perform or "supplant" (Ausburn & Ausburn, 1978, 2003, 2008b) for females the task of mentally combining images from multiple sources, may have assisted them in spatial imagery processing. Cognitive load (Sweller, 1988, 1999) inherent in the visual/spatial processing performed by the subjects was perhaps reduced through the supplantation process. This assistance may have both improved their performance and raised their self-efficacy (Bandura, 1994, 1997) with the VR technology.

However, when the VR environment became unfamiliar, technical, visually complex, and navigationally difficult – as in the second study with the surgical operating rooms – the picture changed dramatically with regard to gender. In the operating room environment, the females appeared to experience more difficulty and to lose the performance and confidence advantage they exhibited in the house environment. When the desktop VR presentations depicted unfamiliar locations, contained visually complex fields full of competing details, and presented complicated navigation options, the gender gap in performance, confidence, and perceived difficulty appeared to re-assert itself. The high levels of visual-cognitive load, necessary spatial processing, and visual orientation/wayfinding/navigation complexity implicit in the virtual operating room environment appeared to result in performance and self-efficacy problems for the females that they did not experience in the more familiar and comfortable house environment. At theoretical level, it could be hypothesized that what may have happened here is that the heavy visual-spatial cognitive load overrode the supplantational benefit of VR and resulted in spatial processing problems, heightened anxiety, and loss of self-efficacy for the females.

The aggregate cross-case findings of these two studies of gender and virtual learning environments suggest that the effects of desktop virtual reality may not be identical for males and females, and that the differences may be exacerbated when VR is used to place female learners in technical settings or settings with visual and navigational complexity. These results tend to support the findings and contentions of much of the research literature regarding gender differences in spatial, orienting/wayfinding/navigating, and technology self-efficacy functioning. An important note for CTE teachers and teacher educators is that these findings also suggest that special care may be necessary to help females benefit from learning opportunities offered by desktop virtual reality technologies, especially in strongly gendered learning situations such as CTE programs in cosmetology and some health occupations. Waller (2000) asserted that female functioning in virtual environments and their ability to benefit from VR training can be improved, and the gender differences reduced or even eliminated, through appropriate training to increase women's proficiency with the VR user interface. This possibility may be particularly important when using VR to instruct females in strongly gendered occupations and classrooms.

Conclusion

Recent improvements in desktop hardware and software have dramatically increased the visual fidelity and the interactivity of desktop virtual reality. The new high-fidelity VR hardware and software options provide access to this exciting technology at costs that can be borne by most schools and at levels of technology skills that can be mastered by many CTE instructors. Increasing numbers of education programs and industries are taking advantage of cost-effective desktop VR technology and are using desktop VR for instruction and for product development and prototyping. Mastery of complex or dangerous environments, risk-free manipulation of expensive equipment, cost-effective product development and evaluation, and interactive exploration of multivariate problems are all now feasible at the desktop in virtual settings. New high-quality desktop VR is now within the technical and fiscal reach of many schools, programs, and instructors. These developments have important implications for CTE in which mastery of such skills are frequently critical in providing optimum curricula.

However, if VR is to reach its full potential as a CTE instructional tool, it will be the task of VR designers to develop, and of CTE instructors to carefully evaluate and select, user interfaces and implementation strategies to overcome gender-specific limitations of this medium. CTE instructors wishing to implement desktop VR in their curricula should be aware of potential gender-related learning issues and take steps to maximize the learning benefits of this exciting new technology for everyone.

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Motivation while Designing in Engineering and Technology Education Impacted by Academic Preparation

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Abstract

The purpose of this study was to determine if high school students' academic preparation was correlated with change in motivation during an engineering design challenge. The research was conducted in a high school classroom in which elements of engineering design were taught in a technology education context to eleventh-grade student from diverse academic backgrounds (measured by grade point average [GPA]). Participant motivation was assessed by the California Measure of Mental Motivation (CM3). The CM3 measures student motivation to apply critical thinking skills and reasoning to solve problems in five subscales: mental focus, learning orientation, creative problem solving, cognitive integrity, and scholarly rigor.

Findings of this study suggested that knowledge of students' GPA served as a predictor of student motivation. With the exception of the mental focus subscale, growth over time was not related to GPA. Change across multiple time points in the other four subscales of learning orientation, creative problems solving, cognitive integrity, and scholarly

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rigor did not show significant correlation with mathematics, science or communication GPA.

Introduction

High school technology education has developed a reputation for providing service to an academically diverse student body under the umbrella of general education. Technology education provides an opportunity to integrate academic material in real problem solving challenges (International Technology Education Association, 2000). Students who excel in the academic areas of mathematics, science and communications find technology education a domain where their strengths are valued. Students who struggle through traditional academic material find context and relevance in technology education courses that may spur excitement and perseverance (Lewis, 2004). In contrast, the study of engineering is intimately related to science and mathematics (Katehi, Pearson, & Feder, 2009). High school students engaged in the study of engineering are often the most successful academically. These students tend to have been high achievers in the core academic content areas.

As the field of technology education considers integration and implementation of engineering (the central focus of which is design), attention must be given to the impact on all students. Will only highly motivated and successful students demonstrate gain in courses where engineering and technology intersect? What will happen to less academically prepared students who traditionally enroll (and succeed) in technology education courses? Will technology education effectively exclude a large subset of the student body by incorporating engineering design principles based challenging core academic areas?

Motivation and student learning have a dynamic and complex relationship. “The challenges of learning for today’s world require disciplined study and problem solving from the earliest grades. To meet the challenges, learners must be motivated to pay attention, complete assignments, and engage in thinking” (Bransford, Brown, & Cocking, 2000, p. 280). Students enter classrooms with a broad range of motivation. Student’s motivation has the potential to increase or decrease over time impacted by many factors including the learning experiences in class.

“Challenges, however, must be at the proper level of difficulty in order to be and to remain motivating: tasks that are too easy become boring; tasks that are too difficult cause frustration” (Bransford, et al., 2000, p. 61). Vygotsky suggested appropriate learning experiences fall within a student’s *zone of proximal development* (ZPD). This zone represents the difference between a student’s individual capability and the student’s potential with support from peers or teachers. Maintaining learning experiences in mixed courses of students challenges the educator to deliver developmentally appropriate materials for a wide range of student needs.

According to the STL (*Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association, 2000), technological literacy is important for all students, and therefore technology education students represent a broad range of academic backgrounds. Thus, it is essential to understand how engineering design challenges affect all students from low to high achievers. If the pedagogical implementation of engineering design challenges is only successful for the highest achieving students, a disservice will be provided to students who are academically less prepared. Therefore, the following research question framed this inquiry: Does a student’s academic preparation correlate with the individual's change in motivation during an engineering design challenge? If growth in student motivation is uncorrelated with an indicator of student success in school, infusing engineering concepts into technology education is likely to be successful for all students, which is consistent with the mission of ITEA as identified in *Technology for All Americans (International Technology Education Association, 1996).*

Motivation

The authors reviewed nine studies that have been published in the past 15 years and focus on the efficacy of engineering design challenges. These studies were concerned with change in motivation among learners in elementary schools, secondary schools, and the college years (Dally & Zhang, 1993; Dunlap, 2005; Griffith, 2005; Lentz & Boe, 2004; Ricks, 2006; Rogers, 2005; Romero, Slater, & DeCristofano, 2006; Roselli & Brophy, 2006; Weir, 2004). In these studies, motivation was assessed using a variety of instruments including course evaluations, surveys, instructor perceptions, and self-efficacy scales. Each study comparing a traditional teaching model to a teaching model employing elements of engineering design challenges showed improvement among students experiencing the engineering design approach. Four of the nine studies reported statistically significant gains ($p < 0.05$). Though improvement was demonstrated, these studies did not disaggregate the data by previous levels of academic performance in order to identify differential effects on more (or less) academically prepared learners.

The construct measured in this study was the motivation to apply critical thinking and reasoning skills to solve problems. The California Measure of Mental Motivation

(CM3) was selected after consulting with the publisher, Insight Assessment. The CM3 measures a student's motivation to apply critical thinking skills and reasoning to solve problems. Five areas were assessed, as explained by Insight Assessment:

1. Mental Focus/Self-Regulation: The person scoring high in mental focus is diligent, focused, systematic, task-oriented, organized, and clear-headed.
2. Learning Orientation: A person scoring high in learning orientation strives to learn for learning's sake; they value the learning process as a means to accomplish mastery over a task. These individuals are eager to engage in challenging activities. They value information and evidence gathering, recognize the importance of giving reasons to support a position, take an active interest and are engaged in school.
3. Creative Problem Solving: The person scoring high in creative problem solving is intellectually curious, creative, has a preference for challenging and complicated activities, and is imaginative, ingenious, and artistic.
4. Cognitive Integrity: Individuals scoring high in cognitive integrity are motivated to use their thinking skills. They are positively disposed toward truth seeking and open-mindedness.
5. Scholarly Rigor: Scholarly rigor is the disposition to work hard to interpret and achieve a deeper understanding of complex or abstract material. A person with a high score on this scale exhibits a strong positive disposition toward scholarly rigor and would not be put off by the need to read a difficult text or to analyze complicated situations or problems. (Insight Assessment, 2007b)

Validity and reliability of the CM3 instrument were considered during the instrument selection process. Reliability has been computed using the Cronbach's alpha (refer to Table 1). In addition to reliability assessments, the CM3 has been studied for its external validity, predictive validity, and discriminant validity. Data supporting the validity is published in the User Manual (Insight Assessment, 2007a, pp. 25-30).

Table 1

Cronbach's Alpha Coefficient for CM3

Focus area	Cronbach's alpha
Learning orientation	.79 - .83
Creative problem-solving	.70 - .77
Mental focus	.79 - .83
Cognitive integrity	.53 - .63
Scholarly rigor	NA

(Insight Assessment, 2007a, p. 27)

Research Site

An eleventh grade high school course was identified which included an academically diverse array of students and provided a semester-long engineering design challenge. This team taught course was described in the syllabus:

> This course will introduce many concepts of engineering and the designing of systems.… The labs will provide a bridge between what we learn in the classroom to practical applications in a real world setting. We will apply technology, and the skills we have learned in math, science and communication to several major projects.

This research setting provided student experiences in technology education focused on fabrication, as well as an understanding of the underlying science and math principles governing the physical world to enable them to design systems and components.

For purposes of this research, an engineering design challenge was defined as a team based activity in which students engage in solving a real world problem. In this engineering design challenge, mathematical models were developed to understand the behaviors of systems. The data extracted from manipulating models served to guide experimentation. Design decisions were made based on model and experimental results.

During the fall semester, teachers provided a foundational knowledge base for the spring term. Students participated in hands-on learning experiences which represent an intersection of technology education and applied physics. For example, students learned physics concepts such as motion, forces, electricity, magnetism and simple machines, as well as technology content such as welding, machining, mechanical fastening, and metal working processes. The concluding projects (1/10 scale model and mini-frame with jig) in the fall term set the stage for design and fabrication of a solution to the engineering design challenge that officially began with the spring term.

The spring term was initiated by assembling teams and focusing on defining the engineering design problem. The problem included the design and fabrication of an ultra efficient competitive electric race car following the Electrathon American design constraints (2007). Teams of students started the engineering design challenge by refining their design based on the $1/10^{th}$ scale model of an electric car and driver. Then teams of 2 to 6 students designed, modeled, and built their full size Electrathon vehicle. Constraints were imposed by the Electrathon rule book and local facilities. Designs were optimized for minimal weight, tire scrub, air resistance, and other characteristics. Analysis was incorporated into the modeling in the form of model car wind tunnel testing, gear ratio calculation, power demand calculation, and ratios of battery life to distance traveled. Understanding of these parameters had been developed in the fall term by building and testing smaller projects such as magnetic levitation cars and calculating horsepower capacity of a student built electric motor.

Participants

The sample included 28 regular education students who completed the course. Female enrollment was 10.7% (n=3). Of the students who chose to report ethnicity, 75.0% (n=21) were Anglo American or Caucasian; 3.6% (n=1) Hispanic, Latino, or Mexican American, 3.6% (n=1) Native American and 17.9% (n=5) reported mixed or other. The proportion of students not reporting as Anglo American/Caucasian was 3.1% higher than the school statistic of 21.9% and comparable to the national demographic of 24.9% (U.S. Census Bureau, 2000). Cumulative GPA had an overall mean of 2.24 on a scale of 0-4. Cumulative GPA ranged from 1.00 to 3.75 and had a standard deviation of 0.80. Participants serviced by special education accommodations were not considered in this analysis.

Methods

The research question for this study was to identify potential correlations between a student's academic preparation and the individual's change in motivation during an engineering design challenge. To address this research question, a repeated measures correlation study was conducted in which data were gathered on student motivation at three points during the academic year. Trends and changes during the year were compared to an indicator of each student's academic preparation.

Data analysis was conducted using longitudinal multilevel modeling techniques. This analysis allowed multiple predictor variables to be analyzed in this repeated measures design for prediction of motivation. "…Applications of multilevel models are longitudinal research and growth curve research, where a series of several distinct observations are viewed as nested within individuals…" (Hox, 2002, p. 1). Predictor variables included high school grade point averages for core academic areas (science, mathematics, and communications), time, section, and demographic information.

In the modeling process, the main effects of predictors were considered in addition to their interactions with time. Interactions between main effects were analyzed including the effect of academic preparation and time. Slopes and intercepts of main effects and interactions were interpreted. This analytic modeling strategy facilitated an understanding of relationship between a student's academic history and changes in motivation during an engineering design challenge.

A main effects only model was created and tested against a main effects model that included interactions of time and each predictor. Significance testing was conducted using likelihood ratio tests comparing the models using *R*. Modeling was conducted with R software version 2.7.0 and the linear mixed-effects models package version 0.99875-9 (Bates, Maechler, & Dai, 2008). Significant interactions were included in a model which was then reduced in a top-down approach. A reduction technique was employed where the least significant predictors were removed one at a time. Each model iteration was compared to the previous model using likelihood ratio test to determine if it was statistically different. This process was employed for each of the five CM3 motivation subscales. First-level units were repeated measures within individual study participants. Data from 83 mental motivation tests were considered for analysis. Second-level units were 28 participants in this study. In the hypothesized models, individuals and time are declared random effects to assess variability among individuals within time points, as well as variability among time points.

Results

The CM3 measured five subscales of motivation: mental focus, learning orientation, creative problem solving, cognitive integrity, and scholarly rigor. Means for each subscale are presented in Table 2 and 4 of 5, show growth over time. Scales range from 0 to 50 and are interpreted by categorization as shown in Table 3. A two-level, longitudinal, multilevel model assessed the effects of grade point average in mathematics, science, and communication courses, course section, and minority status on mental motivation. It was expected that a potential correlation existed between change indicated by the CM3 and GPA.

Table 2

	October n=28		December n=27		April n=28	
	M	SD	M	SD	M	SD
Mental focus	28.50	8.23	28.07	8.27	28.50	8.27
Learning orientation	32.43	5.88	32.30	7.75	33.96	7.92
Creative problem	29.75	8.09	32.48	8.53	32.29	10.03
Cognitive integrity	34.18	6.72	33.44	7.24	34.93	8.68
Scholarly rigor	27.75	4.70	28.15	5.62	28.11	6.01
Average	30.52		30.89		31.56	

Table 3

Score Interpretation for CM3

Score on CM3 scale	Interpretative category
0-9	Strongly negative
10-19	Somewhat negative
20-30	Ambivalent
31-40	Somewhat disposed
41-50	Strongly disposed

Note: Table adopted from California Measure of Mental Motivation Score Interpretation Document (Insight Assessment, 2006)

Mental focus

According to the CM3, a student scoring high in mental focus was diligent, focused, systematic, task-oriented, organized, and clear-headed. Mental focus scores did not significantly increase over time. A full model was developed which included main effects and significant interactions. A parsimonious fixed slope model was reduced from the full model which was not statistically different, $\chi^2(3, N = 83) = 518.7 - 516.7 = 2.0$, $p > 0.05$. No statistically significant main effects were present in the model.

A significant positive interaction was discovered between time and mathematics GPA. This suggested that students with higher mathematics GPA’s tended to gain more over time, illustrated in Figure 1, than did their peers with lower mathematics GPA’s. A significant negative interaction was discovered between time and science GPA, as shown in Figure 2. This negative interaction suggested that lower science GPA students tended to gain more over time than did their higher science GPA peers.

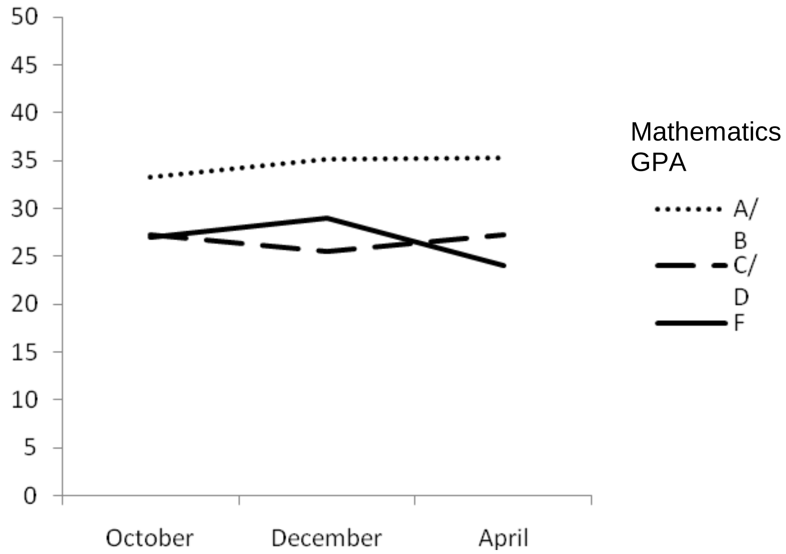

Figure 1. Mental focus scores across time points by Mathematics grade point average.

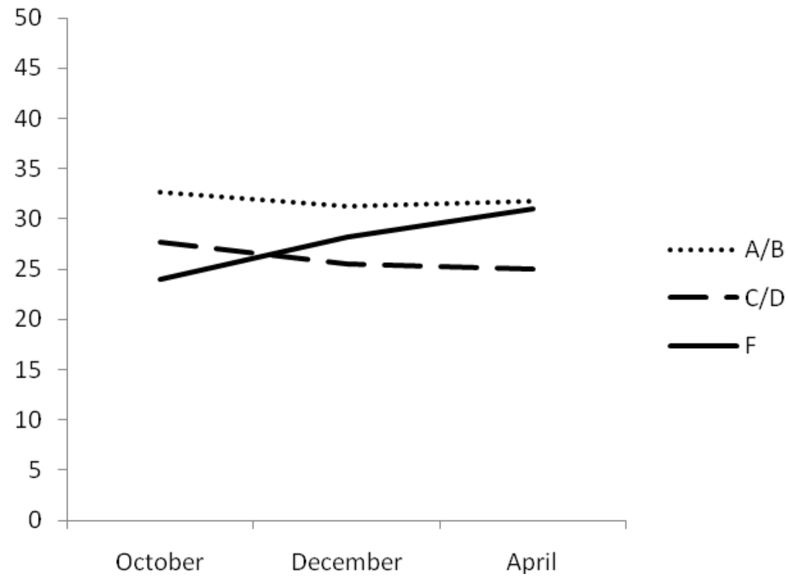

Figure 2. Mental focus scores across time points by Science GPA.

Learning orientation. A student scoring high in learning orientation was motivated by the desire to increase knowledge and skill base as published with the CM3. Learning orientation scores did not significantly change over time. A parsimonious random slope model was reduced from the main effects only model which was not statistically different, χ^2 (4, N = 83) = 530.1 – 531.5 = 1.4, $p > 0.05$. No statistically significant main effects were included in this model. No significant interactions were discovered with any predictor and time, which indicated no significant change over time related to student GPA.

Creative problem solving. According to the CM3, a student scoring high in creative problem solving had a tendency to approach problem solving with innovative or original ideas and solutions. Creative problem solving scores increased significantly over time. A parsimonious random slope model was reduced from the main effects only model which was not statistically different, χ^2 (3, N = 83) = 530.3–527.2 = 3.1, $p > 0.05$. The statistically significant main effect in this model was time. Students' GPA's in science and communications improved the model fit significantly but were not statistically significant predictors. No significant interactions were discovered with any predictor and time, which indicated no significant change over time related to student GPA.

Cognitive integrity. A student scoring high in cognitive integrity was motivated to use thinking skills in a fair minded fashion, seek the truth, and be open minded. Cognitive integrity scores did not significantly change over time. A parsimonious fixed slope model was reduced from the main effects only model which was not statistically different, χ^2 (6, N = 123) = 534 – 531.2 = 2.8, $p > 0.05$. No statistically significant main effects were included in this model. No significant interaction was discovered with any predictor and time, which indicated no significant change over time related to student GPA.

Scholarly rigor. A student scoring high in scholarly rigor tends to work hard to interpret and achieve a deeper understanding of complex or abstract material. Scholarly rigor scores did not change significantly over time. A parsimonious random slope model was reduced from the main effects only model which was not statistically different, χ^2 (5, N = 83) = 469.9 – 469.1 = 0.8, $p > 0.05$. The statistically significant main effect in this model was GPA in science. Students scoring higher in previous science courses tended to score higher than their peers. No significant interactions were discovered with any predictor and time, which indicated no significant change over time related to student GPA.

Conclusion

Mental focus changes over time were negatively correlated with science GPA, meaning the initial score differential (between higher and lower science GPA students) was decreased over time. This statistically significant reduction of the mental focus gap between higher and lower GPA students held a practical significance as mid and high GPA students showed a small decrease in mental focus, while low GPA students showed a more dramatic increase in focus over time. In contrast the mental focus gap between higher and lower mathematics GPA students was increased over time indentified in the positive significant interaction between mathematics GPA and time.

Learning orientation and cognitive integrity were not significantly correlated with cumulative GPA or individual GPAs for math, science, or communications. Students began the semester with a score of approximately 32.4 and 34.2 (scale 0-50) in learning orientation and cognitive integrity, respectively. This indicated that students were “somewhat disposed” to desire an increase in their knowledge, skill base, truth seeking, and open-mindedness (Insight Assessment, 2006). Small, but not statistically significant, increases over time were observed. No significant correlations were discovered with GPA or GPA interacting with time. This indicated that, regardless of GPA, students were equally likely to be interested in increasing knowledge and skill with a fair-minded perspective. A lack of correlation with GPA and time as an interaction factor indicated that higher achieving students did not change over time differently than their lower achieving counterparts.

Creative problem solving was slightly positively correlated with science GPA. Students with higher GPA in science tended to have a higher creative problem solving score, approximately 1.9 points (scale 0 to 50) higher per point on the GPA scale. Mean creative problem solving scores in October were 29.75, and statistically significant gains by April yielded a mean of 32.29. While two point gains held questionable practical significance, the average student did transition from "ambivalent" to "somewhat disposed" to having an increased tendency to approach problem solving with innovative or original ideas and solutions (Insight Assessment, 2006). A slight negative correlation was observed with communications GPA, indicating that higher communication GPA students scored lower on creative problem solving. Gains over time were not correlated to any of the GPA data, which indicated that students, regardless of GPA, tended to increase creative problem solving scores over time at a similar rate.

Scholarly rigor was positively correlated with science GPA. Students with a higher GPA in science tended to score higher in scholarly rigor, approximately 2.1 points (scale 0 to 50) higher per point of GPA in science. Change over time was not statistically significant, nor was it correlated with GPA. Thus, student growth, over time, was unrelated to GPA in science, mathematics, or communications. Student mean scholarly rigor scores in October were 27.75 which increased, but not significantly, to 28.11 in April. This indicated that students were "ambivalent" in their disposition to work hard to interpret and achieve a deeper understanding of complex or abstract material (Insight Assessment, 2006).

Supporting the existing literature base (Dally & Zhang, 1993; Dunlap, 2005; Griffith, 2005; Lentz & Boe, 2004; Ricks, 2006; Rogers, 2005; Romero, et al., 2006; Roselli & Brophy, 2006; Weir, 2004), average motivation, measured pre and post did show improvement. In each of the five subscales of mental motivation, mean scores increased with the exception of mental focus which remained constant.

Discussion

As teachers introduce engineering design concepts into their classrooms, consistent with the *Standards for Technological Literacy: Content for the Study of Technology* (International Technology Education Association, 2000), attention should be given to students' motivation. Motivated students tend to be more easily engaged in learning activities and motivation is a desirable student characteristic to develop. Results of this study suggested that student motivation increased during the engineering design activities. However, mental focus is a subscale that presented a unique interaction with time and both science and mathematics GPA. Educators concerned with increasing motivation of students who are struggling may find these results encouraging. While engineering design activities rely on application of science principles, less academic students engaged in these experiences are showing increased focus over time. The Committee on K-12 Engineering Education may have offered an explanation of the results:

> In theory, if students are taught science and mathematics concepts and skills while solving engineering or engineering-like problems, they will be able to grasp these concepts and learn these skills more easily and retain them better, because the engineering design approach can provide real-world context to what are otherwise very abstract concepts. (Katehi, et al., 2009, p. 51)

Data from this study were unable to explain why highly focused students (with higher science GPAs) showed losses over time. This discovery warrants further investigation but suggested that highly academic students were disengaging over time. It may be the case that instruction in this classroom catered to the middle and lower achieving students and was not developmentally appropriate for the advanced students thus, they were not adequately challenged.

The absence of a significant correlation between four of the five motivation subscales indicated that the introduction of engineering concepts did not have a differential impact on students of various academic backgrounds. This result preserved the positioning of technology education in a general education context. The finding of this study was that students struggling academically were not disadvantaged in terms of motivation as they encountered and experienced engineering design thinking processes. All students benefited from an education that included engineering design thinking.

Recommendations for Future Research

Students in this study were measured during one academic year. This single snapshot of a child's development showed some growth in motivation and may represent a larger pattern. In 12 years of education and potentially post secondary education, does the growth pattern identified and discussed above continue? The holistic impact of a multiyear sequence of articulated technology courses may have some synergistic benefits for students beyond the simple sum of the parts. Educators and policy makers may be better able to allocate resources to support technology education with evidence that students exhibit a sustained increase in motivation.

Students who are highly successful in previous science courses demonstrated a reduction in metal focus while their less successful peers gained. This finding warrants further investigation. Why did these students decline in their motivation? One hypothesis is that the course was not substantially challenging for these students. An alternative hypothesis is that these students were successful in very structured programs of study and found the open ended application of scientific principles to be frustrating. The later hypothesis suggests another complex question about the differences between successful students in mathematics and science. Highly successful students in mathematics did not show a significant decline in motivation in this study.

In this study, students designed, fabricated, tested and redesigned electric powered vehicles. Further research might attempt to isolate what factors regarding design yield the greatest results in terms of motivation and its impact on student learning. *Changing the Conversation* (National Academy of Engineering, 2008) suggested that the public conception of engineering be focused on the societal impacts of solutions. The design challenge for this study was related to developing alternative power technology for transportation. To what extent are the potential environmental and social impacts a factor in the student's interest and motivation in this project? The educator's choice of design challenge may impact student's motivation related to the solution's potential impact on society. Additional study might seek to identify the impact of limiting solutions to conceptual design rather than full implementation cycles. Can high school students learn (and be motivated to learn) successfully from conceptual design, or do they benefit substantially from implementation of the designed solution based on the experiential feedback of success and failures with opportunities for redesign and testing? Full implementation of student designs has the potential to engage the psychomotor domain of student development. Historically, technology education has been very successful and highly regarded for its ability to engage students' psychomotor domains. Further study may discover a link facilitated through design implementation that successfully engages psychomotor, cognitive and affective domains simultaneously.

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A Relational Study of Students' Academic Achievement of Television Technology in Technical Colleges in Delta State of Nigeria

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Abstract

This study examined the relationship between the male and female students' academic achievement in the subject of television in urban and rural technical colleges in Delta State. There are two research questions and one null hypothesis formulated to guide the study. The population for the study consists of 731 students of the six technical colleges in the Delta State offering Television Technology as a subject. No sampling was conducted due to the small number of students involved in the study. The two research questions were answered using percentages while the null hypothesis was tested using ANOVA at 0.05 level of significance. The findings revealed that males performed better than their female counterparts. It was also revealed that urban students performed better than their rural counterparts in NABTEB examinations in 2005 and 2006 respectively. There is no significant difference in the mean scores of male and female students in television subjects in technical colleges. There is a significant difference in the mean scores of students in television in urban and rural technical colleges. Based on these findings, it was recommended that teachers should teach the practical and theoretical aspect of the television subject to improve the academic achievement of students.

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Introduction

One definite thing expected of the educational institution to provide training to meet the demand for the human resource needs of the nation. The training of youth in the technical college aims at equipping them with useful skills and improving their knowledge in their desired areas of study. One such educational program that provides the youth opportunity to acquire skills and knowledge for effective nation building is the technical education program conducted in technical colleges.

Electronics training provides the youth with the practical skills in works pertaining to radio, television, telecommunication, electronic devices and circuit services. However, it has been discovered that the persistently poor performance of students emanates mainly from the inappropriate teaching methods adopted by technical education teachers in the instruction of television.

The realization of the objectives of technical college television programs and to improve students' performance depends to a large extent on a number of factors. These factors include the availability and adequate supply of qualified teachers, provisions of television equipment and facilities, proper implementation and usage of technical education textbooks on television. Blundan and Reddish (2003) explained a television set as electronic equipment that requires a supply of electrical energy from the mains to be converted among other things, into light from the screen and sound from the loudspeaker. But this can only form a meaningful picture and message if there is a further supply of electrical energy to the aerial socket at the back of the television set. They further explained that this can either be, as originally intended, from an aerial picking up energy from electromagnetic radio waves sent out by a television transmitter, or it can be from a video recorder producing a similar energy pattern from programs stored on magnetic tape. In both cases, this second energy supply is called a signal because the amount of energy involved is tiny compared with that supplied from the mains, but it fluctuates in a patterned (coded) way; this ensures that a particular transmitter (or video channel) can be separated out from the others. Therefore, the conversion of main energy into light and sound can be controlled so that the required pictures and speech or music are reconstructed. Thus, a television set is another energy conversion device, to set alongside the machines and heat engines which have contributed so much to the industrial and social fabric of the developing and developed world over the last three centuries.

Technical college students are familiar with radios, televisions, computers, pressing irons, refrigerators and other electronic devices. In this study, knowledge and repair skills of television sets are the basis of modern electronics maintenance and servicing trade and have found wide application in technical colleges (Yalam & Fatuku, 2007). They further pointed out that it is important to familiarize students with the knowledge of television technology because the knowledge of the device is relevant and useful in learning technical subjects. It has been observed that despite the usefulness of television technology the subject in the technical colleges has been on the decline (National Business and Technical Examination Board, NABTEB 2004). One of the reasons for this decline in achievement is due to lack of electricity and funds for teaching of the subjects. The teacher’s mode of instruction and the use of television sets powered by batteries, standby generators, and solar energy to cater for the electricity problems in line with each topic, objective, content activity and specific task in the National Business and Technical Examination Board (NABTEB) syllabus that are applicable for teaching television subject could improve the situation.

Doramola and Emmanuel (2000) stated that most Television Technology technical college graduates experience prolonged trial and error, and consequently perform poorly at the National Technical Certificate Examination (NTCE) and labour trade test examination. Daramola and Emmanuel further pointed out that this unsatisfactory situation could lead to breakdown in the economic, industrial, technological and educational growth of Delta State, since the main goal of technical education is to achieve self reliance. The insistence by these researchers, Doramola and Emmanuel (2000), and Yalam and Fatuku, (2007) suggested the need for this study because of the challenges of increased unemployment (Faruk, 2005).

There is need to investigate the effect of students' academic achievement in television in technical colleges in Delta State. Hence, a study of academic achievements of students in this area appears desirable.

Statement of the Problem

It is apparent that there is an astronomical decline in students' academic achievement in television in technical colleges in Nigeria. Lack of success can lead to inappropriate behavior and frustration on the part of students (Igbo, 2007). In technical colleges, teachers are faced with the task of placing the students in an educational setting tailored to the students' learning. The setting in which services are provided has a strong influence on the academic achievement of the students.

A number of reasons or factors have been found to have contributed to students' poor achievement. Some of these factors include students' study habits and teaching methods used by the teacher in the teaching-learning process (Yalam and Fatiku, 2007: 88). However, some researchers have attributed the poor performance of students to gender, as it is believed that technical trades and related tasks belong to male students. This is reflected in the ratio of male to female student enrollments in technical colleges. They further stated that the environment (urban and rural setting) also influences the academic achievement of technical college students as facilities are not available in rural locations. It appears to the researcher that students' academic achievement in television has been dwindling in recent times and the situation calls for immediate attention in order to arrest this deplorable situation. It is expected of the technical colleges to provide trained manpower in applied technology, particularly crafts and advanced crafts and to provide individuals with knowledge and vocational skills necessary for agricultural, commercial and economic development. It is also meant to provide training and impart the necessary skills on individuals who shall be self-reliant economically (FRN, 2004).

It appears that individuals expected to acquire the knowledge and skills stipulated by the national policy education document are graduating from the technical colleges with unsatisfactory performance. As recorded in NABTEB (2002) from the chief examiner's report, basic electricity students who sat for the examination performed very poorly. Additionally, NABTEB certificate research conducted in Radio, Television and Electronics, May/June, 2004 recorded a 30% failure rate in radio communication, a 60% failure rate in television, and a 27% failure in electronics devices and circuits (NABTEB, 2004). The National Business and Technical Education Board Report (NABTEB, 2004), Grade Distribution from 2000-2003 May/June results revealed failure of 46% of the students who sat for the examination in basic electricity. This raises more questions as to whether or not adapting and understanding their teachers' instructions, there are such factors as issues of males and females, and the enrollment of students in urban and rural areas which also influence this ugly trend. Thus, a correlation study of male and female student's academic achievement in television in urban and rural technical colleges is desirable.

Purpose of the Study

The major purpose of this study is to compare male and female students' academic achievements in television in urban and rural technical colleges in Delta State.

Specifically, the study was meant to:

- Determine any difference in academic achievement of male and female students examined in the television subject in technical colleges in Delta State.
- Determine any difference in academic achievement of students examined in the television subject in urban and rural setting.

Research Questions

The following research questions guides this study.

1. What is the academic achievement of male and female students examined in television subject in technical colleges in Delta State?
2. What is the academic achievement of students examined in television subject in urban and rural technical colleges in Delta State?

Hypothesis

There is no significant difference in the mean academic achievements of male and female students in the television subject in urban and rural technical colleges in Delta State.

Method
Research Design

This study was a survey work which was designed to enquire into and provide information about the achievement of male and female students examined in television subject in urban and rural technical colleges in Delta State.

Area of the Study

The area of study was Delta State. The state has 25 local government areas with six technical colleges.

Population of the Study

The population of the study consisted of students in six technical colleges offering television technology as a subject in the 2005 and 2006 examination year.

- Agbor Technical College, Agbor had **139** students**,**
- Government Technical College, Issele-Uku had **122**,
- Sapele Technical College, Sapele had **134**,
- Ofagbe Technical College, Ofagbe, Sapele had **102**,
- Ogor Technical College, Otogor had **100** and
- Utagba-Ogbe Technical College, Utagba-Ogbe had **134** students.

The information on the student population in each technical college was provided by National Business and Technical Examination Board (NABTEB).

Sampling and Sampling Techniques

No sampling was done. All the students in the six technical colleges were used in the study.

Table I
Institution, Population and Location of Urban and Rural Technical Colleges

S/N	**Institution**	**2005 Population**	**2006 Population**	**Location**
1	Agbor Technical College, (ATC)	80	59	Urban
2	Government Technical College, Issele-Uku (GTC)	68	54	Rural
3	Sapele Technical College, Sapele (STC)	67	67	Urban
4	Ofagbe Technical College, Ofagbe (OFTC)	46	56	Rural
5	Ogor Technical College, Otogor (OTC)	55	45	Rural
6	Utagba-Ogbe Technical College, Utagba-Ogbe (UTC)	69	65	Urban
	Sub-Total	385	346	
	Grand Total	731		

Table I shows the institutions, population of each technical college and their different locations. It was shown in Table 1 that technical colleges close to urban areas are 1st, 3rd and 6th, while the rural technical colleges are 2nd, 4th, and 5th.

Instrument for Data Collection

The documented examination results of National Business and Technical Examination Board (NABTEB) in the 2005 and 2006 examination of six technical colleges in urban and rural settings was the major instrument used at bringing out answers to the research questions raised and the hypothesis formulated in the study.

Validity of the Instrument

National Business and Technical Examination Board (NABTEB) subjected the scores of the students to face and content validation by the experts and professionals in the field of television and electronics.

Reliability of the Instrument

The instrument of the study was established using Kuder-Richardson Formula 20. It was used to establish the internal consistency reliability of the instrument. The 2002 NABTEB examination scores were obtained and used to compute the internal consistency reliability estimates of television subject. The reliability estimate gave the value of 0.79.

Method of Data Collection

The documented examination results of NABTEB of 2005 and 2006 May/June were collected by the researcher from the Asaba office of the Board from the statistics on students' academic achievement in the subject of television in the six technical colleges in Delta State. The report was contained in NABTEB, NTC, NBC May/June 2005 and 2006.

Method of Data Analysis

The stated research questions one and two were answered using percentages. The hypothesis one was tested using the Analysis of Covariate ANOVA because institute and agenda provided the grouping variables and test scores provides on interval.

Decision was established based on rejection of null hypothesis, if the calculated value exceeds the critical value; otherwise the alternative hypothesis should be upheld.

Results

Research Question 1

What is the academic achievement of male and female students examined in television subject in technical colleges in Delta State?

Table II
Mean and Standard Deviation of Male and Female Students Academic Achievement Examined in 2005 and 2006 NABTEB Examination in Television Subject

Gender	Mean	N	Std. Deviation
2005 Male	48.1439	278	13.29888
2005 Female	48.5000	110	13.62725
2006 Male	48.6195	297	11.49971
2006 Female	53.3261	46	14.42383
Total	48.7168	731	12.75772

Table II reflected data of computed scores in 2005; the male students had a mean of 48.1439 with standard deviation of 13.29888, while females had a mean of 48.5000 with standard deviation of 13.62725. In 2006, male students had a mean of 48.6195 with standard deviation of 11.49971 while females had a mean of 53.3261 with standard deviation of 12.75772. In all, Table II reflected a mean of 48.7168 with a standard deviation of 12.75772.

Research Question 2

What is the academic achievement of students examined in television in urban and rural technical colleges in Delta State?

Table III
Mean and Standard Deviation of Students' Academic Achievement in Television Subject Examination in Urban and Rural Technical Colleges

Location of students	Mean	N	Std. Deviation
Students in urban technical colleges	50.2500	404	14.28857
Students in rural technical colleges	46.8226	327	10.27441
Total	48.7168	731	12.75772

In Table III students in urban technical colleges had mean scores of 50.2500 with a standard deviation of 14.28857, while students in rural technical colleges had the mean score of 48.7168 with a standard deviation of 10.27441. In urban and rural locations, the students had a mean of 48.7168 with standard deviation of 12.75772.

Hypothesis 1

There is no significant difference in the mean academic achievements of male and female students in television subjects in urban and rural technical colleges in Delta State.

Table IV
Summary of Analysis of Covariate (ANOVA) of Male and Female Students Scores in Six Technical Colleges in Television Subject in 2005 and 2006 NABTEB Examination

Student scores on television subject * Gender

	Between Groups (Combined)	Within Groups	Total
Sum of Squares	1076.523	117737.860	118814.383
df	3	727	730
Mean Square	358.841	161.950	
F	2.216		
Sig.	.085		

P < 0.05

Measures of Association

	Eta	Eta Squared
Students scores on television subject * Gender	.095	.009

The analysis of variance of students' scores on television subjects by gender shown in Table IV did not reveal any significant difference. The Table reflected the P=0.085 as value computed and F-calculated as 2.216 with 0.05 as a set significant value in the study. Therefore, the students' scores are not associated with their gender. This is supported by the weak measure of association (Eta=0.095 and Eta squared value of 0.009).

Hypothesis 1

There is no significant difference in the mean academic achievement of male and female students in television subject in urban and rural technical colleges in Delta State.

Table V

Summary of Analysis of Covariate (ANOVA) of Urban and Rural Students' Scores in Six Technical Colleges in Television Subject in 2005 and 2006 NABTEB Examination

ANOVA Table

Students scores on television subject * Location of students

	Between Groups (Combined)	Within Groups	Total
Sum of Squares	2122.920	116691.463	118814.383
df	1	729	730
Mean Square	2122.920	160.071	
F	13.262		
Sig.	.000		

$P < 0.05$

Measures of Association

	Eta	Eta Squared
Students scores on television subject * Location of students	.134	.018

The analysis of variance of student scores on television subject by location (urban and rural) shown in Table V revealed a significant difference of (P=0.000) between the urban and rural students in terms of location. This is reflected in the strong measure of associated (Eta = 0.134) and Eta squared value of 0.018, indicating that students' academic achievements are strongly associated with their urban and rural technical colleges.

Discussion

The findings of research Question One revealed that students performed below expectation in the subject of television. In other words, there was a consistently high failure rate in the television subject in 2005 and 2006 NABTEB examination under consideration. Anakwe (2008) revealed in his study that students' academic achievement below average and linked with the student's loss of control and poor school adjustment found in his study habits. Anakwe supported the earlier findings of the study that found performance of students in different technical colleges below expectation.

Research Question Two revealed that there is a difference between the urban and rural students. Anakwe further stated that adjustment of students to school environment (urban or rural) is an important requirement of the life, and efforts should be directed in schools towards making school environments more child-friendly and motivating students to participate in both curricula and extra curricula activities. This may go a long way in improving students' academic achievement and attitude towards work within the technical colleges and the external examination. The mean and the standard deviation analysis of students' academic achievement in television subject indicated that the general proportion of the students had a high failure rate in the examination. A majority of the students were found to be 50 percent below average performance. Umunadi (2009) proffered reasons why there are discrepancies in academic achievement when he said that the discrepancy in performance is that the urban students are exposed to extra-moral lessons, extra-practical orientation during and after school periods and this might enhance their academic achievement in technical college. The hypothesis revealed the analysis of variance of students' scores on television subjects by gender did not reveal any significant difference. The hypothesis revealed that there is a significant difference between the urban and rural technical college students, from the results of 2005 and 2006 tested in the study. It can be inferred that the difference in academic achievement can be a result of students' background and the location of the technical colleges.

Recommendations

Based on the findings of the study, the following recommendations were made for sustainable development in television subjects.

1. Intensive extra-moral class should be organized for television subject students to assist them improve their academic achievement in the external examination.
2. Institutions should strive towards effective instruction theory and practice to enhance academic achievement of students in television subject for sustainable development.
3. Textbook, CD ROM, and internet facilities should be provided for the television subject in technical colleges to enable students to update their knowledge in this area to prepare and pass the subject during the NABTEB examination.

4. Teachers should be given in-service training to update their knowledge in television subject, instructional methods in the classroom and workshops to assist them in teaching the students effectively to improve their academic achievement in the NABTEB examination.
5. Past questions of NABTEB examinations should be used to teach the students during revision and normal class sections to expose the students to the methods of approach and answering the NABTEB questions.

Conclusion

Conclusively, the study attempted to find the relationship between the male and female students' academic achievement in television technology in urban and rural technical colleges. An attempt was also made by the researcher to examine the academic achievement of students in the six technical colleges in Delta State. A survey design was adopted to collect data from 385 and 346 students in 2005 and 2006 examination year respectively. Two research questions and one null hypothesis guided the study.

The study revealed the following findings: that there are high failures rates of the male and female students in the urban and rural technical colleges. There is no significant difference in academic achievements of male and female students in television subject in technical colleges. It was also revealed in the findings that there is a significant difference in the academic achievement of students in urban and rural technical colleges. Based on the findings, it was recommended that intensive teaching, coaching, using past questions of NABTEB examination in the classroom, and extra-moral classes to improve the students' academic achievement in external examination, among others, be implemented.

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UNDER REVIEW

Leadership and Self Deception
By The Arbinger Institute (2000)
Format: (*Paperback, 232 pp. ISBN: 1576750949)*
Publisher: Berrett-Koehler Publishers Inc.

This book was directed primarily to those in the business world, but everyone who works in the field of education in any capacity, yes, everyone, will benefit from the concepts in the book *Leadership and Self-Deception*. No matter how knowledgeable an individual is or how many years of experience he or she has, unless this fundamental concept of self-deception is understood, they will not experience optimum effectiveness. Some of us may instinctively understand this concept and interact in a positive manner most of the time, but we can be self-deceived into thinking we are doing it well when in reality we are not. All of us in education are required to interact and communicate, but this is not effective without understanding how to avoid self-deception.

The book uses a fictional first person narrative to convey the concepts of self-betrayal and self-deception that are common to everyone. The storyline begins with a man named Tom Callum who has been recently hired as a senior management officer for a large company. Within the first month of his employment, he is called in by the company vice president, Bud Jefferson, and is told in a very non-threatening manner that he has a problem. He is told that practically everyone knows about this problem including his coworkers and family, but surprisingly Tom seems to be the only one who does not know about it.

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Bud begins by telling of a personal experience from early in his career. It is easy for Tom to see the self-centered and self-deceived behaviors of his boss as the story unfolds, but cannot see any connection to his own experience.

The story of the book depersonalizes the presentation of the information and makes Tom feel at ease. In the same manner, the fictional storyline of the book makes it easy for the reader to be disarmed, and see applications of the principles in their own lives. The book has numerous illustrations of how the process of self-deception works, but one of the most straight-forward is the one that Bud tells about his newborn infant.

When Bud's first child was only a few months old, he and his wife were in bed, sound asleep, about 1a.m. The baby started fussing and crying and Bud woke up and his first impulse was to get up and tend to the baby. The only problem was that after thinking about it for a few seconds, he realized that he was tired and did not feel like getting up. As he continued to think about it, he reasoned through the situation and decided that his job was to earn the living and the wife's job was to take care of the baby. He decided it was not his problem, and to be fair, his wife should take care of the baby. He reasoned that he had to get up and go to work and that his wife was pretending to be asleep as the baby continued to cry. After telling this, Bud explained to Tom how his not acting on his inclination to help his wife and take care of the baby was self-deception. He pointed out how he was thinking of reasons why she should not do what he felt convicted to do, and to further build his case, he began thinking of his wife in negative ways, imagining her to be lazy and a faker. This is an example of how self-deception begins.

The term used in the book for this self-deception experience is: "being in the box." When we are in the box, we see individuals as objects that are in our way, instead of people with feelings and needs just like us. The storyline of the book continued to develop the concept of self-betrayal revealing that when we are in the box, we inflate the faults of others, inflate our own virtue, inflate the value of things that justify our self betrayal, and place blame on others. When this behavior becomes habitual, we begin to carry these boxes with us, and in many circumstances do not even have the initial inclination to do the right thing.

The story further developed the self-betrayal concept by illustrating interactions between multiple individuals who are "in the box," explaining how that scenario compounds communication and productivity problems. The storyline also explained how our "in the box" actions tend to demoralize those we work with and make them feel unappreciated and unvalued. This, of course, makes a huge negative impact on individual morale and productivity.

In the beginning of the story, Tom was puzzled about how the focus on interpersonal relationships relate to his job, but as the story unfolds he begins to see that the harmony of the employees is a very significant issue in being truly productive. Of course, this is a universal issue in any endeavor where personal interactions are involved.

For those of us in education, what is more important than communicating effectively and bringing out the very best our students are capable of? In this book, self-deception and all of its implications and complications is discussed in great detail. The book does give some great insights on how to "get out" and "stay out of the box," but you will have to read the book to learn the secret.

Improving Your Teaching Using Synergistic Andragogy

Michael Kroth
Bryan Taylor
Larry Lindner
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University of Idaho

Introduction

Synergistic Andragogy (SA) is related to the concept of Synergogy as presented by Mouton and Blake (1984). Synergogy, much like SA, is an alternative mode of education. Mouton and Blake define synergogy as a "systematic approach to learning in which the members of small teams learn from one another through structured interactions" (Mouton 1984, p. xii). Synergogy focuses on learner motivation and involvement, whereas Synergistic Andragogy (SA) focuses on the learning experience and its potentially powerful outcomes. SA is a type of learning which occurs through the interaction of two or more groups of adult learners such that the combined effect is greater than the sum of individual group learning. SA combines two concepts, synergy and andragogy, to create a process that adult educators can use in a variety of environments to create a powerful learning process. Synergism brings two or more forces together based on the belief that joint efforts and combined energies are greater than individual efforts. Research suggests that the value, performance, and power of teams, groups, and collectives are often stronger than individuals acting alone (Katzenbach & Smith, 2003). Andragogy was popularized by Malcolm Knowles, who argued that the adult learning process is significantly different than a child's learning process (Knowles, 1984). Knowles eventually summarized six key assumptions about adult learners, which he said are the foundation of adult learning.

The purpose of this article is to describe an exercise in how SA was executed over one semester through a six step model. The foundations of SA and how we integrated organizational sustainability as the theme is discussed in more detail elsewhere (Kroth, Taylor, & Lindner, *in press*).

Experiences using Synergistic Andragogy in an academic setting

SA was used during one semester to enhance the learning experience of adults enrolled in two separate university-level courses. The following six step process (Figure 1) was undertaken to create a synergistic adult learning environment.

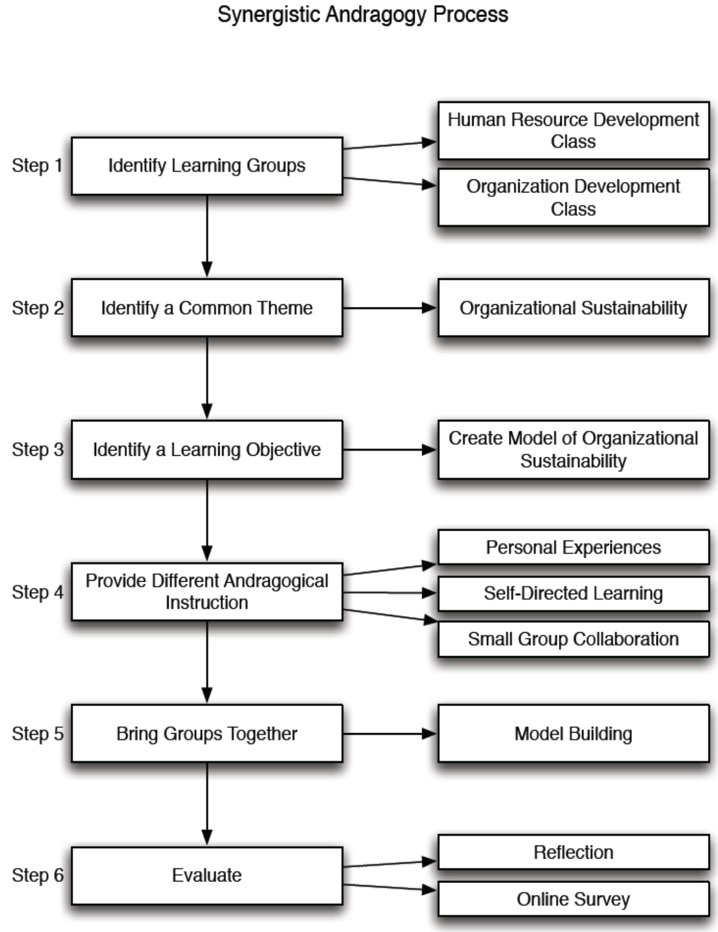

Figure 1: The Six Step Process of SA

Step 1: Identify two or more adult learning groups

Two adult learning groups were identified. The members of one group were students enrolled in a graduate level Human Resource Development (HRD) class. The members of the second group were students enrolled in a graduate level Organization Development (OD) class. The classes were designed as hybrid courses. Each met face-to-face every other week, and online on the alternate weeks using the Blackboard online platform.

Step 2: Identify a common theme central to both groups

"Organizational sustainability" was chosen as a theme to focus on throughout the semester. Sustainability is an important topic these days as environmental issues have moved to the forefront of governmental, corporate, and non-profit agendas and we wanted to make the experience meaningful for students (Lindeman, 1926). For purposes of this exercise, "organizational sustainability" was defined as that which causes organizations to survive and thrive over the long term.

Step 3: Identify a learning objective or end result for students to achieve

The terminal learning objective defined at the beginning of the academic semester was to create a model of organizational sustainability.

Step 4: Provide different means of andragogical instruction

Different andragogical techniques for instruction were then employed throughout the semester. In addition to regular course materials, assignments, reports, and discussions, the instructors started by providing both groups with literature on sustainability. The students were asked to read common articles. Weekly assignments were also included. The focal point of each assignment was to ask students to relate the learning concepts for that week to their own situation or experiences. Each student then shared their assignments with the rest of the class for further discussion. By applying course material to real situations students were also more ready to learn. Allowing for students to hear about others' experiences in completely different backgrounds helped them to more usefully apply the readings and discussions to their own situations.

Students were placed in groups of 5-7 people for the semester. This facilitated more depth of discussion and participation both online and in the classroom, and encouraged self-directed learning and lively online discussion which often ranged into topics not directly assigned but of related interest to students. Often they were dealing with real issues in their own work situations and inquired about approaches to take to solve their individual problems and opportunities.

Step 5: Bring the groups together for a common learning experience

Throughout the semester the instructors provided opportunities for the groups to meet together. Guest speakers would come to discuss topics that were common to both courses and tied to the theme of sustainability.

The classes produced two products through their mutual learning efforts. One was a combined annotated bibliography of articles about organizational sustainability gathered by members of the two classes throughout the semester and compiled by the instructors. The other was a group of four organizational concept maps.

At the end of the semester a joint class meeting was scheduled with the purpose of sharing knowledge gathered throughout the course of the semester. The specific objective of this session was to create organizational sustainability models based upon the information, discussion, and reflection accumulated throughout the semester.

This meeting was the culmination of SA. Four concept maps were developed during that session. The four perspectives led to further discussion about the complexity of organizational sustainability and the differing paradigms that individuals bring to organizational and societal issues.

Step 6: Evaluate

Two forms of evaluation were used. The first was a reflective process between the three instructors. The second was an electronic student survey. Both were qualitative processes that yielded useful insights for future SA learning design.

All three instructors met weekly to evaluate and assess progress throughout the semester. Two of the instructors were students that were co-teaching with the third, a faculty member. This process was an experiment to explore SA, and the instructors learned as much as the students.

Conclusion

Synergistic Andragogy brings multiple groups together to create and/or solve a common objective. The six stages proposed are process steps for SA to occur. Although this work and approach is exploratory, the opportunity to create synergistic learning experiences is an important and potentially useful avenue for both practice and research.

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Thirtieth Annual Outstanding Manuscript Award Recipients

Journal of Industrial Teacher Education

Each year the Editorial Board of the *Journal of Industrial Teacher Education* acknowledges excellence in writing through its Outstanding Manuscript Awards. The Outstanding Manuscript Awards are presented to authors of refereed manuscripts based on three categories: research, conceptual, and dissertation. An awards task force, consisting of past *Journal* editors reviewed each published manuscript from Volume 45 of the *Journal*. The members first determined whether the manuscript merited recognition and then ranked the selected manuscripts. Individual rankings were combined to determine the recipient in each of the three award categories. The awards task force for Volume 45 consisted of Richard Walter, Janet Burns, and George Rogers. The Editorial Board of the *Journal of Industrial Teacher Education* extends warm thanks to these individuals for their assistance in the awards selection process and for their continued service and commitment to the *Journal*, the National Association of Industrial and Technical Teacher Educators and the profession.

The Outstanding Research Manuscript is selected from published articles that were data based. The Outstanding Research Manuscript for Volume 45 was co-authored by James A. Gregson, the University of Idaho, and Patricia A. Sturko, Washington State University. Their article, published in Issue 3, was entitled *Learning and Collaboration in Professional Development for Career and Technical Education Teachers: A Qualitative Multi-Case Study*.

The Outstanding Conceptual Manuscript Award is chosen from philosophical, historical, curricular, or expository pieces. Marie Kraska, Auburn University, authored the Outstanding Conceptual Manuscript for Volume 45 of the *Journal*. Her article entitled *Retention of Graduate Students Through Learning Communities* was published in Issue 2 of the *Journal*.

The Outstanding Dissertation Manuscript award is selected from articles that report the findings of a thesis or dissertation. The Outstanding Dissertation Manuscript for Volume 45 was co-authored by Luke J. Steinke, Eastern Illinois University, and Alvin "Bob" Putnam, Southern Illinois University. Their article, which appeared in Issue 2, was entitled *Influencing Technology Education Teachers to Accept Teaching Positions.* Their manuscript was based on Dr. Steinke's dissertation completed at Southern Illinois University.

The Outstanding Manuscript Award recipients were recognized by the National Association of Industrial and Technical Teacher Educators at their Opening Session held during the Association for Career and Technical Education Conference in Nashville, Tennessee. The recipients were presented plaques for their achievement. Once again, the *Journal* Editorial Board and the National Association of Industrial and Technical Teacher Educators congratulate each of the award recipients of Volume 45.

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Karen F. Zuga	36, 37	1998-2000
Marie C. Hoepfl	38, 39	2000-2002
George E. Rogers	40, 41	2002-2004
Janet Z. Burns	42, 43	2004-2006
Richard A. Walter	44, 45	2006-2008
Robert T. Howell	46, 47	2009-2011

Institutional Members

Ball State University
Manatee County Schools, Bradenton, Florida
Purdue University
University of Southern Mississippi
Temple University
Red River College – Winnipeg, Canada
Indiana State University – Terre Haute, Indiana