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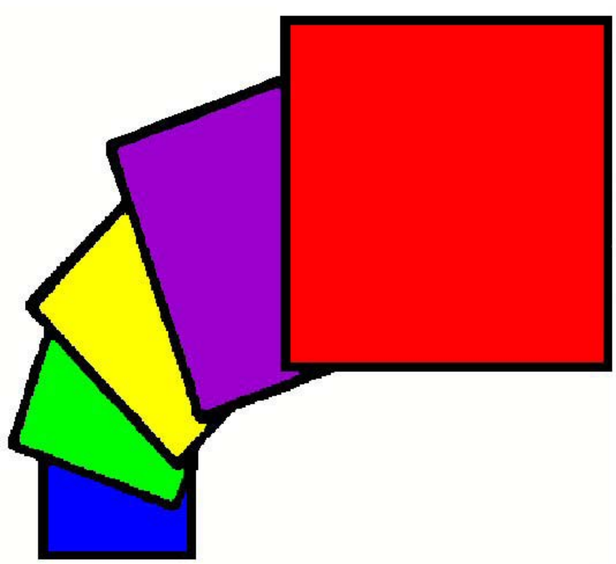

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Journal of Industrial Teacher Education

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JOURNAL OF INDUSTRIAL TEACHER EDUCATION
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Bits and Pieces

Change has been slow but it is coming

The year 2009 is fast drawing to a close and I as I look back at everything that has taken place I think we should call it the "year of change." This change began last November during the presidential elections. Candidates promised us change and I think we can truly say we have seen change in our political system, relations with other countries, the economy, and unfortunately unemployment.

Our political system, relations with other countries and the economy are not the only places that change has taken place in this country. Changes in our educational system have been coming for a long time and industrial technology education has not been spared. We are facing some major changes in the way we do things in order to meet the needs of industry and to stay abreast of changes happening in the world today. We need to adapt to change in order for this country to get through the tough times we are facing today and industrial technology should be leading the way.

As I prepared this issue of *The Journal of Industrial Technology Education* (JITE) Volume 46-2, I realized that it is undergoing a change also. Many of the authors in this volume are new, with refreshing ideas and important research. In the last volume (46-1) of JITE we issued a call for graduate papers. This request was answered and many of their manuscripts appear in this volume. The first graduate paper appears in the **At Issue** section: *Students Must Understand Both Theory And Practice*. Kevin Kaluf, a graduate student, along with Kara Harris authored this article dealing with the need and importance of Industrial Technology Education to train future engineers and technically skilled workers to meet the growing demand in this country.

An added bonus is in this volume is a second **At Issue** article written by another graduate student, Karina Baltierrez, whose article titled, *Unlearning How I Have Been Taught*, explains why she feels that we need to develop new teaching methods and styles to reach today's students. Thomas Kraft submitted a very timely **Under Review**, a book explaining how to *Build Your Own Electric Vehicle*. He states that this book provides all the information you need to construct your own electric vehicle which with today's high energy cost isn't a bad idea.

There are four very interesting research manuscripts in the volume that challenge readers to look at old ways in a new way and gain a new prospective of important issues in industrial technology education. Problem Solving has been a topic in the field for a long time. Jeremy Ernst's *Contextual Problem Solving Model Origination* provides the reader with a method to analyze components, sequencing, and challenges associated student problem solving models. Paul Munyoufu and Richard Kohr investigated several aspects of occupational skill assessment in their research *A Calculus of Occupational Skill Attainment: Building More Validity into a Valid Assessment System*.

Mark Threeton and Richard Walter provided readers with an insight on how to better meet the individual education needs of the learner in their manuscript *The Relationship Between Personality Type And Learning Style: A Study Of Automotive Technology Students*. In their research they sought to identify personality types and to see if there was a relationship between personality classification and learning style. Todd Kelley and Robert Wicklein authored the second of a three part manuscript *Examination of Assessment Practices for Engineering Design Projects in Secondary Technology Education*. Their research deals with the importance of infusing engineering content into industrial education classes, provides an in-depth study of engineering in our schools and provides the research needed. in addition it validates what Laluf and Harris wrote in their **At Issue** article.

Volume 46-2 should provide readers with new ideas for change and I hope it will encourage more interesting manuscripts and research in the field.

Examination of Assessment Practices for Engineering Design Projects in Secondary Technology Education (Second article in 3-part series)

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Introduction

There is a growing interest in the topic of engineering design for technology education. At the 2007 and 2008 International Technology Education Association (ITEA) conference held in San Antonio, over 80 presentations were related to engineering topics. Further evidence of the influence and impact of engineering design content comes from the large number of well documented curriculum projects designed to infuse engineering content into technology education such as *Engineering by Design*; *Project ProBase*; *Project Lead the Way*, and *Introduction to Engineering* (Dearing & Daugherty, 2004). Likewise, state curriculum standards exist for the teaching of engineering design in technology education (Massachusetts Department of Education, 2001, Advisory Committee on Engineering and Technology Education in Georgia. (2008). Moreover, authors in the field of technology education have provided a strong rationale for engineering design to be the focus for technology education (Hill, 2006; Lewis, 2004; Wicklein, 2006). In a very short time, the field

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has moved from "coming to terms" with engineering design (Lewis, 2005) to research studies that suggest the technology education teachers value this focus and are already on the move towards infusing engineering design into technology education (Dearing & Daugherty, 2004; Gattie &Wicklein, 2007; Kelley, 2008). Based on these efforts to infuse engineering practices within the technology education curriculum it is appropriate to now investigate how technology education teachers are assessing engineering design activities within their classrooms. This research study was guided by the following questions:

1. To what degree do current assessment practices of secondary technology educators reflect engineering design concepts?

2. What are the similarities and differences of assessment practices of secondary technology educators when grouped by traditional and block schedules?

3. What are the greatest and least emphasized engineering design assessment practices by secondary technology education teachers?

Related Literature

Welch (2001) indicated that research on assessment practices in technology education was sparse. Furthermore, Lewis (2005) indicated that assessment of the teaching and learning of design was still an undeveloped aspect of technology education. Arguably, design has been at the center of technology education teaching and learning for some time and therefore should also be at the center of assessment criteria. Lewis (2005) provides a strong rational that design is the single most important category in the Standards for Technological Literacy (ITEA, 2000/2002). Design, as a subject and as a process as outlined in the Standards, is the catalyst to explain and understand how all man-made things work which fall within the domain of engineering. Lewis identified that of the twenty standards in the document, four directly address design. However, Lewis also indicated that assessment of the teaching and learning of design was still an undeveloped aspect of technology education. Several studies in technology education have focused on the assessment of design, engineering design, and problem solving. Halfin (1973) was a pioneer in the development of a coding process to assess an individual's design and problem solving thought process. Halfin used biographical and autobiographical data to evaluate the intellectual processes used by ten high-level designers (e.g., Buckminster Fuller, Thomas Edison, Frank Lloyd Wright) to solve technological problems. Halfin employed the Delphi research technique to identify 17 mental processes that were universal for these expert engineers and designers. Halfin's coding process has been used in several research studies using an observation protocol methodology to assess students' design and problem solving capabilities (Hill, 1997; Kelley, 2008). Similar studies have also used observation assessments to evaluate students engaged in the design process and these methods have been found to be an effective assessment technique (Lewis, Adams, Punnakanta, Littleton, & Atman, 2001). Custer, Valesey, & Burke (2001) developed and validated an instrument for assessing student learning in design and problem solving. This research was founded on the concept that problem solving can be condensed into a set of discrete, observable behaviors able to be captured using appropriate rubrics. The examples of research in technology education that focuses on assessing students' abilities in design and problem solving listed above have provided a foundation of knowledge to build upon, but there is clearly a need for more research on assessment of engineering design thinking.

One recent study sought to identify appropriate assessment strategies for engineering design at the secondary level. This Asunda and Hill (2007) study determine the critical features of engineering design that can be incorporated within technology education learning activities. The researchers also developed a rubric for assessing these identified features. The study used a phenomenological approach through a semi-structured interview process working with three professors of engineering education. The interview process revealed four core themes for emphasis in technology education with an engineering design focus. The four core themes were (a) the process of engineering design; (b) societal benefits of engineering design; (c) attributes of engineering design; and (d) assessment. Qualitative data from the interviews of the participants revealed that participants used a variety of assessment practices to evaluate students design projects including; a) student portfolios, b) assessment by a panel of engineering faculty for industry based-projects, and c) individual and group presentations. This data was used to construct an assessment rubric for evaluating the design (process and product), the communication (oral and written), and the teamwork demonstrated throughout the activity.

Methodology

This descriptive study drew a full sample of high school technology teachers from the current ITEA membership list (September 2007). 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. 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. A cover letter was sent electronically through e-mail for all ITEA members in the sample who listed an active e-mail address in the fall of 2007. The electronically delivered cover letter contained a URL for the on-line questionnaire. The on-line questionnaire was managed by HostedSurvey.com. 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 population of 1043 high school ITEA 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).

Instrument

Results of Asunda and Hill's (2007) study created a framework in the survey instrument to identify appropriate assessment strategies for secondary technology educators when assessing engineering design activities. The researchers used the elements from Asunda and Hill's rubric to create eight instrument items related to assessment practices for engineering design projects. See Table 1 for a complete list of the eight individual instrument items for assessment practices.

Table 1. Assessment Practices for Engineering Design Projects

Individual Items of assessment practices for engineering design projects
1. use support evidence / external research (research notes, illustrations, etc)
2. provide evidence of formulating design criteria and constraints prior to designing solutions
3. use design criteria such as budget, constraints, criteria, safety, and functionality
4. provide evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)
5. properly record design information in an engineer's notebook
6. use mathematical models to optimize, describe, and/or predict results
7. develop a prototype model of the final design solution
8. work on a design team worked as a functional inter-disciplinary unit

Participants were required to respond to each curriculum content item in two ways, (1) the *frequency of using the assessment practices* and (2) the amount of *time per typical use* of the assessment practice. A six-point Likert type scale was used to collect this data, see Table 2.

Table 2. Teaching Style Scale Conversion

How Often? (Frequency)			
Likert	Wording	Traditional (meets 5 days a week)	Block
0	**Never**	0	0
1	**A few times a year**	5 days	5 days
2	**1 or 2 times a month**	14 days (1.5*9.1)	7 days (1.5*4.6)
3	**1 or 2 times a week**	55 days (1.5*36.8)	28 days (1.5*18.4)
4	**Nearly everyday**	129 days (3.5*36.8)	64 days (3.5*18.4)
5	**Daily**	184 days	92 days

How Many Minutes? (Time)			
Likert	Wording	Traditional (50 minutes per period)	Block (90 minutes per period)
0	**None**	0 min.	0 min.
1	**A few minutes per period**	5 min.	9 min.
2	**Less than half the period**	15 min.	30 min.
3	**About half**	25 min.	45 min.
4	**More than half**	37.5 min.	67.5 min.
5	**Almost all period**	50 min.	90 min.

Assumptions: Traditional schedule meets 5 days a week, 50 minute period, 184 day school year. Typical A/B and 4x4 block scheduling meets for 92 days for 90 minutes.

Limitation

In order to determine statistical significance for this population size N =1043, Krejcie and Morgan's (1970) method was to locate sample size for a given population size; the required sample size for the size of this population was set at 285 (Gay & Airasin, 2000). Again, the survey was sent out to all secondary education ITEA members in order to increase the chances of achieving an appropriate response rate. The final results of the study yielded a total of 226 respondents; therefore, the results of this study cannot be generalized to the entire population. However, the researchers compared the demographic data results of this study with demographic results of a similar national status study of technology education (Gattie & Wicklein, 2007) that did receive a response rate level to generalize to the population. The demographic results of both studies were very similar, thus suggesting that these results were representative to the population. However, the researchers acknowledged that statistical significance was not achieved in this study.

Results

The top mean scores for individual items were as follows: *provide evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)* (mean of 2.92), *develop a prototype model of the final design solution* (mean of 2.69), *and work on a design team as a functional inter-disciplinary unit* (mean of 2.53). Overall, the assessment practice category yielded relatively low mean scores for a 5 point Likert scale, none of which yielded a mean of 3 or higher. The lowest mean scores were items *using mathematical models to optimize, describe, and/or predict results* (mean of 1.72), while *proper record design information in an engineer's notebook* also yielded a low mean of 2.01. See Table 3 for total results of the assessment practice category.

Table 3. Assessment Practices for Engineering Design Projects Results

Assessment practices	*M f*	SD *f*	*M* Time	SD Time
• use support evidence / external research (research notes, illustrations, etc)	2.32	1.38	2.25	1.37
• provide evidence of formulating design criteria and constraints prior to designing solutions	2.33	1.45	2.19	1.43
• use design criteria such as budget, constraints, criteria, safety, and functionality	2.45	1.34	2.31	1.39
• provide evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)	2.92	1.46	2.69	1.50
• properly record design info in an engineer's notebook	2.01	1.76	1.78	1.64
• use mathematical models to optimize, describe, and/or predict results	1.72	1.43	1.62	1.39
• develop a prototype model	2.69	1.43	2.87	1.55

of the final design solution				
• work on a design team worked as a functional inter-disciplinary unit	2.53	1.50	2.79	1.60
Total Group Mean	2.37		2.31	

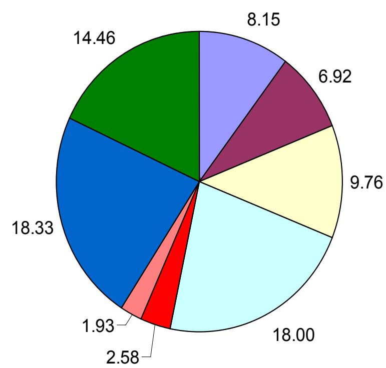
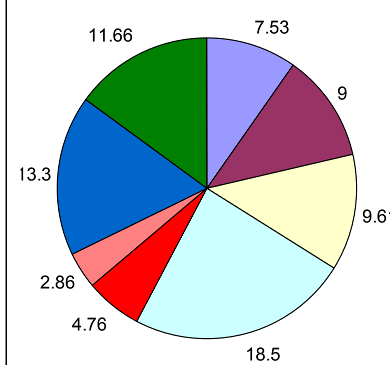
A composite score was generated for assessment strategies for traditional and block scheduling (see Figure 1). Computing a composite score for the assessment practices of high school technology teachers by using mean scores for time per typical use and frequency of use provided an indicator to reveal areas of emphasis and deficiencies regarding assessment practices. The researchers split the files; separating traditional and block scheduling results in order to accurately calculate a composite score. Splitting the file was necessary because the units of day and units of duration were different between the groups. A comparison of the difference between the total hour composite score for each of the assessment strategies between the two groups is reported in Table 4.

Table 4. Comparison of Difference of Total Hours Between Traditional (T) and Block (B) Schedule for Assessment Practices

Engineering Design Assessment Strategies	Total Hours (T)	% Hours (T)	Total Hours (B)	% Hours (B)
• use support evidence / external research (research notes, illustrations, etc)	8.15	10.18	7.53	9.75
• provide evidence of formulating design criteria and constraints prior to designing solutions	6.92	8.65	9.00	11.66
• use design criteria such as budget, constraints, criteria, safety, and functionality	9.76	12.19	9.61	12.45
• provide evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)	18.00	22.47	18.5	23.96
• properly record design information in an engineer's notebook	2.58	3.23	4.76	6.16
• use mathematical models to optimize, describe, and/or predict results	1.93	2.42	2.86	3.70
• develop a prototype model of the final design solution	18.33	22.84	13.30	17.22

• work on a design team worked as a functional inter-disciplinary unit	14.46	18.02	11.66	15.10
Total Hours	80.13		77.22	

Figure1. Composite Score for Assessment Strategies Based on Time Per Use

Traditional Schedule: Total Hours Per Assessment Strategy	Block Schedule: Total Hours Per Assessment Strategy
	

Key Individual Items of assessment practices for engineering design projects

- 1. use support evidence / external research (research notes, illustrations, etc)
- 2. provide evidence of formulating design criteria and constraints prior to designing solutions
- 3. use design criteria such as budget, constraints, criteria, safety, and functionality
- 4. provide evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)
- 5. properly record design information in an engineer's notebook

- 6. use mathematical models to optimize, describe, and/or predict results
- 7. develop a prototype model of the final design solution
- 8. work on a design team worked as a functional inter-disciplinary unit

Comparisons of the difference between the total hours and % of total hours for each of the assessment strategies between the two groups are reported in Table 4. The differences in total hours between traditional and block scheduling was analyzed to determine if there were major differences between the two groups for each of the assessment strategies. The assessment strategy that assessed the *developing a prototype model of the final design solution* received the greatest total hour difference of 5.03 hours. The assessment strategy that required students to *use design criteria such as budget, constraints, criteria, safety, and functionality* resulted in the greatest consensus among responders with only a 0.15 of an hour difference with traditional scheduling dedicating 9.76% and block scheduling dedicating 9.61% of their time on this assessment strategy. The assessment strategy that focused on the *use mathematical models to optimize, describe, and/or predict results* resulted in the lowest emphasized item for assessment practices with traditional scheduling teachers dedicating 2.42 % and block scheduling teachers dedicating 3.70 % of their time utilizing this assessment practices. Over one third of the time technology education teachers spent on assessing students engineering design projects was devoted to two items: *evidence of idea generation strategies (e.g. brainstorming, teamwork, etc.)* with 22.47 % for traditional and 23.96 % for block scheduling, and the item *develop a prototype model of the final design solution* with 22.84% for traditional and 17.22% for block scheduling.

Conclusions

According to the results of this study, secondary technology education teachers place the lowest emphasis on assessing the use of mathematics to optimize and predict design results (Traditional 2.42 %, Block 3.70% of assessment practice time). These results are strong indicators that the engineering analysis phase of the engineering design process is not emphasized very much in assessment practices. This is a major concern considering a number of leaders in technology education have indicated that a major difference between the technological design process and the engineering design process is *analysis* and *optimization* (Hailey, et al., 2005; Hill, 2006; Gattie & Wicklein, 2007) . Without a strong and consistent emphasis on the analytical process to solve technological problems students and teachers are limited in their ability to utilize a comprehensive engineering design process therefore defaulting to the standard trial and error methodology to solve problems. It can be argued that the mathematical modeling and analysis is the heart of engineering design and that without this focus on the design process little or no actual engineering is taking place. This is an important issue to consider especially when it has ramification of damages to the reputation of the technology education field. Individuals inside as well as outside the field of technology education might have rationale to accuse technology education of once again changing the name on the door and not changing the practice (Clark, 1989). Sanders (2008) has observed that many technology education teachers are fond of the appeal of integrating math and science into technology education; when in reality it is rare for technology teachers to identify specific science and mathematical concepts as student learning outcomes for their lessons or activities. Sanders goes on to state "…it is even rarer for technology teachers to assess a science or mathematics learning outcome" (2008, pp. 20-26). Technology education teachers are still emphasizing the importance of building prototyping in their assessment practices. The assessment item *developing a prototype model of the final design solution* just edged out the idea generation item as the top assessment strategy for traditional schedule teachers with 22.84% of their time dedicated to assessing prototypes; this assessment strategy was the second highest emphasized for block scheduling teachers with 17.22% of their assessment time dedicated to this category. Allowing students to build prototypes is an appropriate and important part of the engineering design process. However, constructing prototypes without first using mathematics and science to optimize and predict design results is not authentically engaging in the engineering design process. A strong rationale for implementing the engineering design process over other design processes (e.g., trial and error) is that engineering design requires mathematical and scientific analysis to fully inform the designers to allow them to make educated decisions regarding optimal design before prototype building begins. Technology education teachers who indicate that they are implementing an engineering design process and not requiring or assessing students engaged in some mathematical predictions before prototyping are still using the "trial and error" method and are not truly engaging in the power of the engineering design process.

Another area of lesser emphasis was assessing student's record keeping of design information in an engineer's notebook (2.01 mean for frequency of use, 1.78 mean for time per typical use). It is unclear if technology educators are implementing the use of engineer's notebooks in the classroom and just not using them as an assessment tool. Engineer's notebooks are not only used in engineering schools at the collegiate level, they are also used in engineering practice; therefore technology educators who use engineering notebooks to assess students' design thinking and record keeping skills would be implementing an authentic assessment technique. Moreover, Hill (2006) suggests implementing the use of an engineering design notebook can help students use a systematic approach to design and problem solving.

Another low mean score item was *providing evidence of formulating design criteria and constraints prior to design solutions* (Mean of 2.33 (time); Mean of 2.19 (frequency)). Identifying constraints and criteria early in the design process is an important feature of the engineering design process but is a practice not widely adopted within the field of technology education (Hill, 2006). The low mean score of this individual item confirms this statement.

Summary

As a field, we should review the results of this study (see Figure 1) and ponder on the statement by Young and Wilson: "assessment is a public declaration of what is valued" (2000, p ii). This is an appropriate time to reflect upon the purpose of technology education. Can technology education provide a real-life context for the application of mathematics and science through an engineering design focus? Or is this approach to curriculum revision just another way to legitimize the subject of technology education by using the term engineering? (Lewis, 2004).

The researchers recognize that it is unlikely each of the assessment practices identified in the instrument would or should have equal emphasis by the classroom teacher. However, when research results indicate that items such as *using mathematical models to optimize, describe, and/or predict results* receive less than 4% of the total year of assessment time, it strongly indicates that this is a category of engineering design assessment not widely used as assessment criterion. For years, technology educators have been encouraging students to design and build the fastest model car (LaPorte, 2005), the strongest model bridge (Volk, 1996), or the highest reaching rocket (Hill, 2006) it is the researchers belief that the time has come for technology educators to aspire to help students to use mathematics and science to make the most educated decisions regarding their design solutions. One strong indicator that the field of technology education has truly begun to infuse engineering design into the classroom will be when students begin approaching technology teachers and say "According to my calculations, we are not ready to build the prototype because the current design will not work". This statement will likely never happen and the field will not authentically infuse the engineering design process unless technology educators implement and assess the use of mathematical models to predict design results and optimize student's final design solutions.

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Contextual Problem Solving Model Origination

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Abstract

Problem solving has become a central focus of instructional activity in technology education classrooms at all levels (Boser, 1993). Impact assessment considerations incorporating society, culture, and economics are factors that require high-level deliberation involving critical thinking and the implementation of problem solving strategy. The purpose of this study was to analyze components, sequencing, and challenges associated with technology education student identification and development of problem solving models that factor societal, cultural, and economic considerations. Additionally, this study investigated individual problem solving strategies concerning methods, solutions, and abilities. This study identified that there is no apparent effect on initial component selection of problem solving modeling whether challenged with environmental or manufacturing issues. Students highlighted problem identification as the initial phase of the developed models. Perception of technology education student problem solving ability is high, but students tend not to vary from prescribed categorical stage models that are commonly demonstrated and used in the teacher preparation program.

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Introduction

The method by which students learn, think, reason, process information, sequence operations, and determine solutions to open-ended problems has and will be continually investigated. Research concerning mental processes of students is determinedly pursued in efforts to capture higher understandings of student cognition. A 2006 study by Chrysikou conducted at Temple University suggests that problem solving is an active expression of goal-directed cognition. “Problem solving refers to a situation in which the solver develops and implements plans with the intention of moving from a problem state to a goal state within a range of constraints” (Chrysikou, 2006, p.935). Problem solving and design includes not only the enhancement of initial ideas but also associated research, experimentation, and development (McCade, 1990).

Problem solving is plainly an essential ability in our technologically advanced world. Leaders in government, business, and education have insisted on heightened emphasis on higher-order thinking skills and problem solving in both general and technological areas (Wu, Custer, & Dyrenfurth, 1996). An increased understanding of how students employ problem solving processes and their relation to absolute solutions is important to improve students’ problem solving performance (Stein & Burchartz, 2006). Technology education and problem solving have an existing congruence stemming from the fact that technologies are, in many ways, a product of problem solving (DeLuca, 1991). Technological problems necessitate the application of knowledge from an array of disciplines required to effectively develop and test solutions while considering potential impacts.

Impact assessment and analysis are major considerations in critical thinking and problem solving (specifically technological problem solving). This processes of assessment and analysis evaluates the most extensive vision of issues and inquires about related benefits and deficiencies. The results assist in uncovering planned, unplanned, intended and unintended, desirable and undesirable factors (Deal, 2008). True critical evaluation of problem solving processes includes impact considerations incorporating society, culture, and economics. Porter, Rossini, Carpenter, Roper, Larson, and Tiller, (1980) indicate that social, cultural, and economic feasibility gauging cost versus benefit in its framework is a vital component of technological impact assessment and analysis. Social analysis gauges the impacts of technology on people, while cultural impact assessment involves change to the standard, values, and beliefs systems that channel and rationalize their thoughts and perceptions of themselves or group (Burdge & Vanclay, 1995). Economic analysis in technological impact assessment refers directly to potential profitability and propositions for broader interests. However, the border amid social and economic impacts in areas without quantifiable costs and benefits is ambiguous. Impact analyses generally proceed from assumed models with pre-established systematic relationships composed of elements and components that are parallel in structure (Porter, Rossini, Carpenter, Roper, Larson, & Tiller, 1980).

Among the considerations in problem solving processes specific strategies and approaches are employed. A systematic approach of arriving at a solution to a specified problem is a balanced and reflective practice that enhances outcome (Pol, Harskamp, Suhre, & Goedhart, 2009). Such systematic approaches encompass sequencing targeted tasks and mental processes in an operable and logical order. However, Moreno (2006) indicates in the work of Pol, Harskamp, Suhre, and Goedhart (2008) that instructional programs are not to directly teach students how to solve problems, but instead focus on general process steps. This prevents the development of students who simply follow procedures and allows them to further explore aspects of problem-solving that enables reaching solutions to diverse problems.

Research Questions

This research study analyzed components, sequencing, and challenges associated with technology education student identification and development of problem solving models that factor societal, cultural, and economic considerations. Additionally, this study investigated individual problem solving strategies concerning methods, solutions, and abilities. The following questions guided this study:

1. Does content (environmental and manufacturing) influence initial sequencing of problem solving?
2. Does content (environmental and manufacturing) influence placement of societal, cultural, and economic considerations in original problem solving models?
3. Do students associate problem solving with the design of a tangible artifact?
4. What are students' perceptions of personal problem solving abilities, methods, and solutions?
5. What do students find the most challenging about the development of an original problem solving model?
6. Can students generalize problem solving models to other technology education content areas?

Hypotheses were derived, where appropriate, to provide specific evaluation of research Questions 1, 2, and 3: a) There is no difference in how students presented with environmental issue challenges and manufacturing issue challenges commence with problem identification in model development; b) there is no difference in the way students presented with environmental issue challenges and manufacturing issue challenges position and sequence social, cultural, and economic considerations in design/problem solving models; c) there is no difference between students presented with environmental issue challenges and manufacturing issue challenges product design components in problem solving. Research Question 4 was evaluated through an instrument designed to determine perceptions of problem solving. Research Questions 5 and 6 were evaluated through supplemental questioning of participants.

Participants

Participants in this study were enrolled in a technology education teacher preparation program during the 2008 Fall Semester. Specifically, the participants were students in one of two courses: Emerging Issues in Technology, or Manufacturing Technology. The Emerging Issues in Technology course explores contemporary agricultural, environmental, and biotechnological topics. Students complete associated learning activities, experimentation/data collection exercises, and modeling projects. In the Manufacturing Technology course, students study product design, production system design, and manufacturing organization. Students are required to design, operate, and evaluate a classroom manufacturing system.

These two courses were selected as a result of the coordinated course offerings at the institution, separation of the content between courses, and the anticipated academic level of the students enrolled in the courses. Students in the Emerging Issues in Technology course and the Manufacturing Technology course are in the secondary level of their major and typically student teach the following semester or spring semester of the following year. Students enrolled in these courses have existing knowledge bases and experiences associated with materials and processes, energy and power infrastructures, electronics, robotics, engineering graphics, architectural graphics, and other engineering design principles and processes. Participants in the selected courses of the post-secondary technology teacher education program may have been previously enrolled, although not gauged in information and data collection for this study, in technology education at the secondary or middle grades level. Additionally, participants were not simultaneously enrolled in both courses but may have completed one of the courses in a previous semester. Table 1 and Table 2 provide more detailed demographical breakdowns of student participants in the Emerging Issues in Technology course and the Manufacturing Technology course.

Table 1.
Emerging Issues in Technology Demographics

Gender n - (%)	Male	16 - (94%)
	Female	1 - (6%)
Age Range n - (%)	18 - 20	2 - (12%)
	21-23	12 - (70%)
	24-26	1 - (6 %)
	27+	2 - (12 %)
Major n - (%)	Technology Ed.	15 - (88%)
	Tech./Graphics	2 - (12%)

Table 2.
Manufacturing Technology Demographics

Gender n - (%)	Male	13 - (72%)
	Female	5 - (28%)
Age Range n - (%)	18 - 20	5 - (28%)
	21-23	11 - (61%)
	24-26	1 - (5.5 %)
	27+	1 - (5.5 %)
Major n - (%)	Technology Ed.	10 - (55%)
	Tech./Graphics	8 - (45%)

The majority of the Emerging Issues in Technology and Manufacturing Technology student participants were male, in the 21-23 years of age category, and Technology Education majors. The two student groups in this study consist of 35 participants. Of the 35 participants, 29 were male, 23 were in the 21-23 years of age category, and 25 were majoring in Technology Education. In the teacher preparation program, students also double-major and minor in Graphic Communications. The two groups identified in the study are representative of all sole major and major/minor classifications.

Methodology

The researcher developed a research proposal, submitted and received administrative approval by the Institutional Review Board. After approval, instructor permission was requested and granted to use one agreed upon 45-minute course segment at the beginning of each course's laboratory class meeting. The researcher prepared two concise (seven slide) PowerPoint presentations. One presentation was prepared for the Emerging Issues in Technology course and one presentation was prepared for the Manufacturing Technology course. The presentations were identical in content but presented slightly different challenges. The content portion of both presentations consisted of five design/problem-solving models: 1) The Technology Problem-Solving Model (MacDonald & Gustafson, 2004), 2) The Integrated Problem-Solving Model (Wilson, 1999), 3) The Problem-Solving "Bases" (Nichols, 2004), 4) The General Problem-Solving Process (Cisco, 2007), and 5) The Engineering Design Process (NASA, 2008).

The Technology Problem-Solving Model, described and graphically represented by MacDonald and Gustafson (2004), is a cyclical process that highlights the basic features of a problem, a plan, an implementation strategy, and an evaluation. This model focuses on the representation of the stages through sketching and/or drawing. Wilson's Integrated Problem-Solving Model begins with problem identification and concludes with a solution statement. Each of the four component parts of the model (identification, definition, resolution, and statement) are retraced if an unsatisfactory or unrefined solution is reached instead of restarting the process with initial problem identification. The Problem Solving "Bases" described by Nichols (2004) operates on the processes of rethinking, redefining, and redesigning. A key feature of this model is to build consensus and support before settling on a course of action. Assessment of effects and consequences are taken into account and adjusted before future action is taken. Cisco's General Problem-Solving Process creates a flow of activities where facts are gathered, possibilities are considered based on those facts, and a plan is developed. Unlike many of the other models, there is a resolution stage after results are observed where major problems cease; then the process is terminated. NASA's Engineering Design Process is also represented in a cyclical formation that features the specification of design components. Criteria and constraints serve as the basis for evaluation of designs or prototypes. These models all contain unique components or features within their specified processes that encompass the predominant features in many contemporary problem solving/design models.

A component overview was conducted for each problem solving/design method by projecting the five model's graphical organization and highlighting essential process features. The Emerging Issues in Technology course was challenged to generate an environmental issue problem-solving model that factored social, cultural, and economic concerns, while the Manufacturing Technology course was challenged to generate a manufacturing issue problem-solving model that also factored social, cultural, and economic concerns.

The instructor asked students to brainstorm and develop a unique model that provided their challenges. Using two blank sheets of white lineless paper and a felt tip black marker, they had ten minutes to brainstorm by writing and/or sketching on the first sheet of paper and fifteen minutes to generate and finalize their models on the second sheet. Once all students had completed their original models, a 25 question survey instrument was distributed. The Problem Solving Inventory instrument took approximately ten additional minutes to complete. The instructor asked participants to staple their model to the survey and turn it in for evaluation.

Four students from the Emerging Issues in Technology group and four students from the Manufacturing Technology group were selected at random through course roll assignment and computerized number generation. The researcher requested that they answer four supplemental questions in an interview format:

- What did you find the most challenging about the development of an original design/problem solving model?
- What makes this a universal model given the assigned _______ (environmental or manufacturing) issue?
- Where did you position social, cultural, and economic considerations in your model (early, middle, or end) and why?
- Will your model also serve as a design/problem-solving model for _______ (environmental or manufacturing) issue?

After student participant willingness was confirmed, the eight (four in each group) selected participants were relocated into an adjacent meeting room where a digital recorder and individual stand microphones were set-up for the supplemental questioning. The students were presented with their original design/problem solving models for reference. The researcher read each question aloud to each participant in a rotational format. Participants were allowed as much time as needed to respond to each question, averaging approximately one minute and thirty seconds, before moving to the next participant. The audio recordings of the supplemental questions were transcribed and analyzed.

Instrumentation - The Problem Solving Inventory

The 25 question survey instrument was adapted from "The Problem Solving Inventory" developed by researchers at the University of Central Florida (Heppner, 1988). The initial instrument was generated and tested to assess problem solving qualities of special event professionals to be used in the development of an educational training module. The original instrument contained 35 questions with Likert-type response options ranging from 1=strongly agree to 6=strongly disagree.

The instrument was modified to include 25 questions while maintaining the Likert-type response options ranging from 1=strongly agree to 6= strongly disagree. Some statement wording was changed to target identified process problems instead of problems associated with personal difficulties as previously assessed in the original instrument.

Data Analysis and Findings

Student participant original model information, student adapted Problem Solving Inventory ratings, and student supplemental question transcriptions were entered, coded and analyzed. The sets of data were analyzed through nonparametric methods, as they do not rely on the estimation of limits describing the distribution of the variable being investigated within the population. Therefore, the methods do not require observations drawn from a normally distributed population while still allowing valid inferences about the samples.

The first hypothesis evaluated was: There is no difference in how students presented with environmental issue challenges and manufacturing issue challenges commence with problem identification in model development. This hypothesis was evaluated in Table 3 using the nonparametric Mann-Whitney test. The test statistic for the Mann-Whitney test was compared to the designated critical value table based on the sample size of each student participant group. The participant data for both sample sizes was less than 50, denoting that no normal approximation with continuity correction was necessary and the reported p-value is exact. The critical alpha value was set at 0.05 for this investigation. The p-value for the test (0.9761) was determined to be larger than 0.05, therefore, the null hypothesis failed to be rejected. The analysis of data suggests that content area has no apparent effect on the initial component of problem solving modeling.

Table 3.
Design/Problem Solving Modeling – Problem Identification

Environ-mental (n)	Manufac-turing (n)	Diff. Est.	Test Stat.	P-value
17	18	0	305	0.9761

The next hypothesis evaluated was: There is no difference in the way students presented with environmental issue challenges and manufacturing issue challenges position and sequence social, cultural, and economic considerations in design/problem solving models. This hypothesis was evaluated in Table 4 using the Kruskal-Wallis Test. The Kruskal-Wallis Test ranks designated elements from lowest to highest in the two designated samples.

The sampling distribution for the H statistic was used to test the null hypothesis. The calculated values for the H statistic were evaluated in comparison to the critical values to determine if the null hypothesis is rejected or if there is evidence that fails to reject the claim. The H statistic is less than the critical value so the null hypothesis is not rejected. The analysis suggests that participants challenged with the environmental issue sequence social, cultural, and economic considerations in a significantly different manner than students challenged with the manufacturing issue.

Table 4.
Design/Problem Solving Modeling – Social, Cultural, and Economic Sequencing

	Environmental	Manufacturing	
N	17	18	
DF	1	1	
Median	2	3.5	
Average Rank	13.941176	21.833334	
Chi Square			6.2308598
P-value			0.0126

The final hypothesis evaluated was: There is no difference between students presented with environmental issue challenges and manufacturing issue challenges product design components in problem solving. This hypothesis was evaluated in Table 5 also using the nonparametric Mann-Whitney test. The test statistic was compared to the designated critical value table and the p-value was determined (0.0173). The analysis of data suggests that participants challenged with the manufacturing issue developed problem solving models that necessitate the design of a tangible artifact to a significantly different (higher) degree than students challenged with the environmental issue.

Table 5.
Design/Problem Solving Modeling – Tangible Design

Environmental (n)	17
Manufacturing (n)	18
Diff. Est.	0
Test Stat.	364.5
P-value	0.0173

The 25 question survey items were categorized into problem solving methods, problem solving solutions, and problem solving abilities. Ten survey items pertained to problem solving methods, seven items pertained to problem solving solutions, and eight items pertained to problem solving abilities. Table 6 provides a frequency and proportional account of the three categories for both groups. Emerging Issues in Technology student participants predominately "moderately agree" or "slightly disagree" with the statements concerning their problem solving abilities, proficiency in utilizing effective problem solving methods, and proficiency in selecting appropriate solutions when presented with a problem. The Manufacturing Technology student participants were found to answer much the same as they also predominately "moderately agree" or "slightly disagree" with the statements concerning their problem solving abilities and proficiency in utilizing effective problem solving methods. However, the participants predominately "strongly agree" or "moderately agree" with statements concerning proficiency in selecting appropriate solutions when presented with a problem. Further, an additional Wilcoxon hypothesis test was conducted to determine if there was a statistically significant difference between the Emerging Issues group and the Manufacturing

Technology group. The calculated proportional value exceeded the critical alpha value set at 0.05, therefore, failing to reject the additional null hypothesis refuting difference. Provided information supplied by this additional evaluation, it is verified that student participants in the two groups perceive statements of problem solving methods, solutions, and abilities in a similar manner.

Table 6.
Categorical Results for Emerging Issues in Technology and Manufacturing Groups

	Methods	**Solutions**	**Abilities**
Strongly Agree n – (%)	44– (11%)	19 – (9%)	36 – (15%)
Moderately Agree n – (%)	111– (38%)	53 – (28%)	93 – (40%)
Slightly Disagree n – (%)	92 – (37%)	48 – (25%)	54 – (23%)
Moderately Disagree n – (%)	42 – (12%)	42 – (22%)	33 – (14%)
Strongly Disagree n – (%)	16 – (2%)	30 – (16%)	19 – (8%)
Total Categ. Response n	305	192	235

The supplemental question interviews for the Emerging Issues in Technology group and the Manufacturing group identifies that student participants found the creation of a unique model that does not employ generic sequences as the most challenging. Additionally, steps that incorporate social, economic, and cultural considerations were difficult to design.

Supplemental Question 1 - Emerging issues student:

"The largest challenge was straying away from the models that were shown as examples. I thought that they all have universal characteristics that are necessary in any model, but to consider social, cultural, and economic impacts in all aspects of problem solving you have to start fresh. It was hard for me to develop a brand new process that would help incorporate those factors that was workable."

Supplemental Question 1 - Manufacturing student:

"It was difficult to vary from the run-of-the-mill manufacturing design problem solving models. Models have general characteristics that they (the models presented) all possess. An original way to approach manufacturing issues was difficult."

Both student groups indicated that models could be considered universal by their general and broad nature. Adaptability in a model is considered a necessary component to be applicable in a variety of situations and applications. The rationale for designing each model to be inclusive was the broad challenge presented.

Supplemental Question 2 - Emerging issues student:

"They are generalized steps. They are not specifically geared toward targeted problems, but more general issues. This makes it adaptable to other areas."

Supplemental Question 2 - Manufacturing student:

"This (the student's original model) was made to be very general for the purpose of solving not only specific manufacturing problems but general manufacturing problems. The more specific you get, the less it applies. Using this approach makes it very much universal."

Students have a tendency to position social, cultural, and economic considerations in multiple positions throughout their problem solving models. Recurring consideration and reflection of social, cultural, and economic factors are present. This permits potential and actual impacts of the anticipated/final solution to be evaluated.

Supplemental Question 3 - Emerging issues student:

"I put economic, social, and cultural considerations in two places - one at the top and one at the bottom. Economic, social, and cultural considerations appear in my model while you generate solutions and after you define the problem. This allows you to consider impacts during the development phase. Additionally, after the selection and implementation of a solution, these should be considerations to properly evaluate effectiveness. This allows you to not only predict these impacts but also observe them."

Supplemental Question 3 - Manufacturing student:

"Social, economic, and cultural considerations were placed early because they are an extremely important part of the process. They appear so that through the rest of the process, they are reflected. They were also placed at the end to check the solution for suitability."

Students in both the Emerging Issues in Technology group and the Manufacturing Technology group indicate that their models could also serve as a design/problem-solving model for environmental or manufacturing issues. These responses primarily reference earlier individual statements from Question 2: What makes this a universal model given the assigned _______ (environmental or manufacturing) issue?

Discussion and Conclusions

This study identified that there is no apparent effect on initial component selection of problem solving modeling whether challenged with environmental or manufacturing issues. Students in both groups frequently highlighted problem identification as the initial phase of the model. By the strict definition of problem solving, the process begins with the onset of the problem or a "problem state".

Overall, participants challenged with the manufacturing issue developed problem solving models that necessitate the design of tangible artifacts. Prototypes and physical artifacts of learning through problem solving are considered to be important components for manufacturing students in the teacher preparation program. This information carries over into curricula content and process considerations, spurred by student expectation.

Student participant problem solving inventories provided information that the two groups perceive statements of problem solving methods, solutions, and abilities in a similar manner. Based on the data analyzed in this study, it is concluded that the student participants' problem solving perceptions are not considered separated or dissimilar, eliminating the potential that student participant groups have strongly varying perceptions of problem solving methods, solutions, and abilities. Student perception is relatively high in problem solving. Repeated successful problem solving and design experiences in previous coursework in secondary education and in the post-secondary teacher preparation program surely have heightened problem solving perceptions. However, beyond the scope of this study lies open-ended investigation and structured design experiences with minimal criteria and constraints. The supplemental questioning uncovered that student participants find it difficult to vary from prescribed models that are commonly demonstrated and used in the teacher preparation program. Based on the indicative evidence in this study, this has been identified by the researcher as an area warranting future investigation.

Technology education integrates problem solving methodology into teaching and exploratory practices. Problem solving has become a central focus of instructional activity in technology education classrooms at all levels (Boser, 1993). Impact assessment considerations involving society, culture, and economics are factors that require high-level deliberation involving critical thinking in not only the generation of problem solving models, as in this study, but also the approach and implementation of problem solving strategy.

Problem solving strategy and sequencing of problem-based operation must persistently be evaluated. More research should be conducted on early actions of students within problem solving processes. The findings from this study suggest that a general problem solving model can serve for sets of categorized content in technology teacher preparation programs. The data collected and findings from this study leave the researcher with two main questions: 1) Will a standard problem solving format work for all students? 2) If yes, is it a cross-disciplinary approach? The principal problem-solving approaches in K-12 curriculum in the United States define and solve problems focused on social needs using a cross-disciplinary approach (Black, 1998). This technology and society approach engages in the study of technological innovation as it associates with social change. Technology education has the potential to serve as the catalyst and integrator for cross-disciplinary problem solving studies.

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The Relationship Between Personality Type And Learning Style: A Study Of Automotive Technology Students

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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 individual education needs of the learner, this study (a) sought to identify the predominant personality type of postsecondary automotive technology students and (b) examined whether there was a relationship between the participants' predominant personality classifications and learning styles. The findings suggested that the majority of participants had a predominantly Realistic personality classification, and identified a relationship between personality type and learning style. Findings may be useful to CTE teachers and teacher educators interested in diversifying curriculum and instruction via strategies to enhance the educational experience for the student learner.

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Introduction

Historical Perspectives

Throughout our educational pursuits, many have had a teacher from whom it was difficult to learn. It may have been trouble understanding an educational subject that didn't particularly correspond with one's personality, or it may have been a pedagogy related issue. 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 preferred teaching style. Unfortunately, there is not a "one-size fits all" approach to teaching and or learning (Jorgensen, 2006). Thus, this creates a mismatch 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 adaptive strategies of teaching to meet the learning needs of students. Learning style research has also provided valuable insight regarding the relationship between personality type and learning style. However, this research does not in most cases specifically align with a CTE setting. For this reason, it may be difficult to fully comprehend the relevance of personality and learning style literature to CTE without highlighting the related research.

Over the years, a majority of studies have examined the relationship between personality and learning via the Myers-Briggs Type Indicator (MBTI). One such study by Fallan (2006) suggested that a student's personality type relates to the most effective form of learning and if ignored can present a conflict in the educational process. Another study conducted by Highhouse and Doverspike (1987) examined the relationship between measures of cognitive style (i.e., learning style), occupational preference (i.e., personality type) and learning modes of 111 psychology students (48 males and 63 females) at the university level utilizing Kolb's Learning Style Inventory (LSI), the Group Embedded Figures Test (GEFT) and Holland's Vocational Preference Inventory (VPI). With the means, standard deviations, and intercorrelations measured, the results of this study revealed no significant correlations between the LSI and the GEFT. However, there were correlations found between Kolb's LSI and Holland's VPI which parallels the Self-Directed-Search (SDS) instrument. Kolb's Concrete Experience (CE) scale significantly correlated with Holland's Artistic (A) personality type. Kolb's Active Experimentation (AE) scale significantly correlated with Holland's Realistic (R), Social (S), Conventional (C) and Enterprising (E) personality types. Furthermore, Kolb's Reflective Observation (RO) scale significantly negatively correlated with Holland's R, C and E personality types. Finally, Kolb's Abstract Conceptualization (AC) did not correlate with any of Holland's personality types.

A similar study conducted by Penney and Cahill (2002) examined the work personality and learning style of 60 adult male correctional institution parolees on the Avalon Peninsula of Newfoundland utilizing Holland's SDS (Form E), Kolb's LSI and a Career Counseling Preferences Questionnaire (CCPQ). The results revealed: (a) a positive relationship between the LSI and the CCPQ Thinker score; (b) Holland's Investigative (I) personality type was positively correlated with Kolb's AC and AC - CE score; (c) Holland's I personality type was negatively correlated with Kolb's AE score; (d) Holland's A personality type was found to be negatively correlated with Kolb's RO score; and (e) Holland's C personality type was negatively correlated with Kolb's AE and AE - RO score. Penney and Cahill were forthcoming in identifying that "none of the significant correlations found by Highhouse and Doverspike between the LSI styles and Holland type were replicated in this study" (p. 33).

Another noteworthy study, somewhat related to CTE, conducted by Ritchie (1975) sought to determine if there was a relationship between personality type and the learning style of nursing students and registered nurses via the MBTI and the Media Effectiveness Chart (MEC). The MEC instrument was utilized within this study to correlate preferred instructional media (learning style) with the Jungian personality types. The study findings suggested that there was a relationship between personality and learning and that nursing education programs should be structured to accommodate student development and educational needs. Moreover, Ritchie found that the majority of participants represented within this study were of the Sensing type. Thus, they were identified as needing specific objectives spelled out for learning and evaluation. The results of this study further suggested that the majority of nursing students and registered nurses preferred lecture, discussion, small group work, reading articles, and laboratory work as methods of teaching.

The aforementioned studies have served to highlight the research conducted on the relationship between personality and learning style. 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 and personality type characteristics has the ability to enhance the educational experience for the learner. There are several themes that can be observed by examining the related personality and learning style literature. First, a relationship between personality and learning style has been identified in select educational settings. Second, the majority of studies, which found a relationship between personality and learning style, used the MBTI. Third, besides the study conducted by Ritchie (1975) on nursing students and registered nurses, research on the relationship between personality and learning styles in CTE is virtually nonexistent. Thus, research on the relationship between personality and learning style within an educational setting such as the trade and industry sector of CTE could yield valuable data regarding how to better meet the educational needs of students in preparing them for the world-of-work.

Statement of 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 need to stress the development of the individual and the whole learner. Learning styles, as well as personalities should be accounted for when considering the topic of curriculum development and instruction. With the overload of curricular assessment demands, and a vast amount of learning style models, educators may find themselves in a state of confusion regarding the use of learning style models in the classroom (Hickcox, 2006). This phenomenon creates a problem that requires attention.

While several studies have examined the relationship between learning style and personality type, few have examined the trade and industry sector of CTE. Thus, this study sought to determine whether a relationship exists between the personality type and learning style of postsecondary automotive technology students. 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. Thus, this study sought to answer the following questions:

1. What is the predominant personality type of postsecondary automotive technology students?
2. Is there a relationship between the postsecondary automotive technology student predominant personality type and their learning style?

Theoretical Framework

The theoretical framework that was used for this research study included Holland's Theory of Vocational Personalities and Environment and Kolb's Experiential Learning Theory (ELT). While most closely associated with the career development domain of education, John Holland's Theory of Vocational Personalities and Environments is one of the most popular and effective career development models to date. Holland's Theory (1997) explained that personalities and occupational environments can be classified into six different categories (Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C)) thus, individuals search for an environment in which to express their interest, abilities and values (see Figure 1).

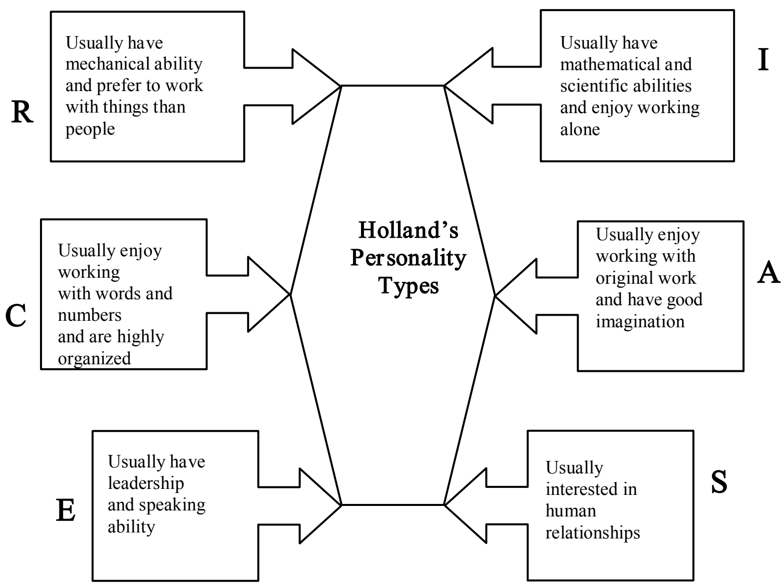

Figure 1. Holland's six personality classifications (1997)

Holland identified that people, in most cases, cannot be classified as a pure type but rather are a combination of two or three. Holland's Theory naturally aligned with this study as the research examined both an occupational area (i.e., automotive technology) and personality type. One of the most popular instruments used to identify an individual's personality and environmental type based on Holland's Theory is the Self-Directed-Search (SDS). The SDS is a self-administered, scored and interpreted educational assessment tool, which attempts to identify a three-letter code in order to determine the personality and environmental type which best represents interests, abilities and values of the individual (Holland, 1971).

The second theory that served as a foundation for this research study was Kolb's ELT (1984). Kolb's ELT (2005b) identified two dialectically related modes of grasping experience: Concrete Experience (CE) and Abstract Conceptualization (AC) and two dialectically modes of transforming experience: Reflective Observation (RO), Active Experimentation (AE). Thus, based on the preferences for one of the polar opposites of each of the aforementioned modes appears four learning styles including: Converging, Diverging, Assimilating and Accommodating (Evans, Forney & Guido-Dibrito, 1998) (see Figure 2). Kolb's ELT naturally aligns with this study as the research focused on the learning style of postsecondary automotive technology students. Kolb's ETL uses an instrument known as the Learning Style Inventory (LSI) to assess individual learning style. 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, 2005b).

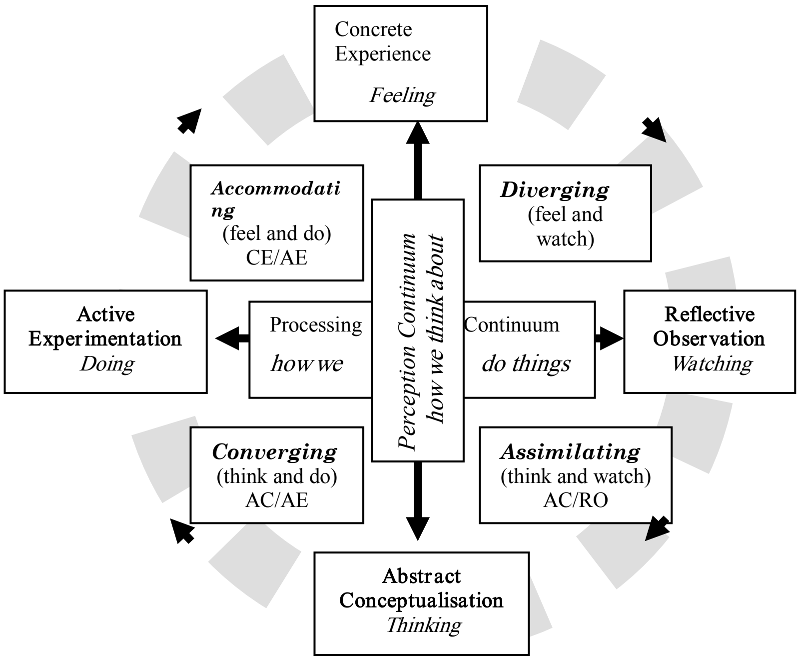

Figure 2. Kolb's learning styles (Chapman, 2006)

Methods

Target Population

Since there is a lack of research on the relationship between personality and learning style in CTE, the study examined this topic through the lens of the trade and industry sector of the profession. The target population for this study was postsecondary automotive technology students in the central region of Pennsylvania. Postsecondary automotive technology students eligible to participate in the study were defined as: (a) first or second year students currently enrolled in a postsecondary automotive technology program in central

Pennsylvania 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 to repair automobiles, trucks, buses, and other vehicle repairs on virtually any part or system through a combination of classroom instruction and hands-on experience; and (c) currently enrolled students are at least 18 years of age or older.

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 these institutions' registrar offices, during the spring semester 2008, there were a total of 310 postsecondary automotive technology students in central Pennsylvania. Thus, 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). In order to obtain an acceptable sample size, postsecondary automotive technology students completed surveys administered by the primary investigator in the participants' classroom setting.

Instrumentation

A quantitative research methodology was used to conduct the study. The specific method chosen to investigate the research questions was a series of three paper form questionnaires. The first questionnaire was a participant background information survey, containing a series of questions relating to: gender, age, career plan, automotive work experience, secondary auto-tech course completion and program satisfaction. The remaining two questionnaires included the Self-Directed-Search (SDS) and Learning Style Inventory (LSI).

Validity and reliability for SDS

The SDS is available in several versions by age as well as for youth and adults (Holland, Powell & Fritzsche, 1994). This study utilized the adult Form R, 4th edition of the SDS since the sample is drawn from a population of adult postsecondary automotive technology students. Based on a sample of college males and females, Holland et al. (1994) identified the internal consistency reliabilities of the SDS as ranging from .90 to .93. Evans, Forney and Guido-Dibrito (1998) pointed out the test-retest reliabilities ranged from .76 to .89 over a four to twelve-week period for high school, college and adult respondents. According to Rayman and Atanasoff (1999), the SDS has well documented empirical validity. In fact, the SDS instrument is offered in several different languages and has reported similar results in different countries (Holland & Gottfredson, 1992). Concurrent validity is measured by "hits" that "equals the percentage of a sample whose high point code and one-letter aspirational or occupational code agree" (Holland, Fritzsche & Powell, 1997, p. 14). Average interest inventories have validity hit rates ranging from 40 to 55%. However, the most recent version of the SDS was found to be at the high end of this range (54.7%) (Holland et al. 1997).

With instrument validity concerns, and since the SDS is predominantly used for linking personality to career choice, the primary investigator sent Dr. John L. Holland a copy of the proposed research study along with a letter requesting his professional input. Dr. Holland responded with a personal phone call. When asked whether it appeared unwise to use the SDS as the personality instrument in this research study Dr. John L. Holland stated:

> I've never seen any version of the SDS used for this purpose. However, given that your study is dealing with aspects of both personality and occupational

> environment in automotive it seems very appropriate to use the SDS for this study. I have no reservations about my instrument being used for this purpose. I would however suggest using the Form R version since your participants are college students. In the past I saw a similar study on the relationship between personality and learning style. I think it used the MBTI as the personality assessment. The results suggested there was a relationship, but the correlation was very weak if I recall. I'll be interested to see the results of a similar study, which uses the SDS rather than the MBTI. (personal communication, November 28, 2007).

While the SDS has typically been used in linking personality to career choice, the six different personality and environmental types highlight specific characteristics, with the ability to identify the personality type of the adult postsecondary automotive technology students within this study.

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 research 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 allotted 90 minutes of in-class time for data collection.

Beginning in January of 2008, thirteen 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 adult postsecondary automotive technology student prior to completing the survey instruments. First, the participants were instructed to complete the general background information survey. Second, students were asked to complete the SDS (Form R 4th Edition) instrument. Third, students were asked to complete the LSI (3.1 Version) instrument. Fourth, and finally, participants were extended a thank you and 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, twelve 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%.

Background of Participants

Demographic data were collected from participants via a background information survey asking six questions regarding gender, age, career plan, automotive work experience, secondary auto-tech course completion status and current program satisfaction. Table 1 summarizes the demographic data collected from the background information survey.

Table 1
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

Analysis of Data

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 focused on first identifying the predominant personality type of postsecondary automotive technology students and second examined whether there was a relationship between their predominant personality type and learning style.

This study first sought to determine the predominant personality type of the subjects. The first research question was answered by calculating the frequencies and percentages of the personality data collected from the completed SDS instruments. The personality type with the highest frequency and percentage was identified as predominant. Second, the study sought to identify whether there was a relationship between the respondent's personality and learning style. To answer the second research question, participants first completed the LSI to identify their learning style. Question two was specifically answered by examining the completed SDS and LSI data through a Chi-square analysis of association. Finally, the background information was analyzed by calculating the frequencies and percentages of the data collected from the background information survey. The data were analyzed using the Statistical Package for the Social Sciences (SPSS v16, 2008).

Research Question 1

What was the predominant personality type of postsecondary automotive technology students? The first research question was answered by calculating the frequencies and percentages of the personality type data collected via the SDS instrument. After calculating the results of the SDS, it was determined that the Realistic personality type was the predominant classification of 148 (84.1%) participants within this study (see Table 2).

Table 2
Distribution of Participant Personality Types (n = 176)

Personality Type	*n*	%
Realistic	148	84.1
Investigative	3	1.7
Artistic	6	3.4
Social	3	1.7
Enterprising	14	8
Conventional	2	1.1
Total	176	100

Note. (a) Realistic types usually have mechanical and athletic ability, (b) Investigative types usually have mathmatical and scientific ability, (c) Artistic types usually enjoy creating origional work, (d) Social types usually have strong social skills and enjoy working with people, (e) Enterprising types usually have leadership and speaking skills, (f) Conventinal types usually enjoy working with words and numbers (Holland, 1997).

Personality Type and Learning Style Relationship

Research Question 2

The second research question sought to identify whether there was a relationship between the postsecondary automotive technology student's predominant personality type and learning style. To answer this question, participants first completed the LSI to identify their learning style. The results of the LSI were much more equally distributed than the personality classifications of the SDS. 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 information and putting it into logical form (Kolb & Kolb, 2005b).

Research question two was addressed by a 4x2 crosstabulation analysis conducted using the four learning styles with Realistic classification and an "all other type" personality category. The "all other type" personality category consisted of the five remaining personality types. This 4x2 Chi square analysis was conducted to correct for expected frequency cell counts of less than 5 exceeding the 20% criterion (Utts & Heckard, 2002, p. 460) observed within the learning style and personality distribution. The results of the 4x2 Chi square analysis revealed no statistically significant association between the personality types and learning styles. However, the basic descriptive statistics related to the distribution of learning style and personalities are still valid (see Table 4). This 4x2 Chi-square analysis revealed one cell (12.5%) with expected counts less than 5, which is within the acceptable range of less than 20% (Utts & Heckard, 2002, p. 460).

Table 4
Crosstabulation of Learning Style by Personality Type (n = 176)

Learning Style	Personality Type	
	Realistic	All Other Types
Accommodating	56 (31.8%)	14 (7.9%)
Diverging	30 (17%)	7 (4%)
Converging	36 (20.5%)	4 (2.3%)
Assimilating	26 (14.8%)	3 (1.7%)
Total	148 (84.1%)	28 (15.9%)

$\chi 2(3,N=176)=2.84$, $p < .417$.
Note. 1 cell (12.5%) has expected counts less than 5. The minimum expected count is 4.61.

Since the results displayed within Table 4 revealed no statistically significant association, a 4x 1 Chi-square analysis was conducted between the four learning styles and the predominant Realistic personality type. The results of the second Chi-square analysis revealed that there was a statistically significant relationship between the predominant Realistic personality type and the Accommodating learning style of 56 participants (37.8%) (see Table 5). Holm's sequential bonferroni post-hoc (1979) method was used to control for type 1 error at $p<.05$ across all comparisons.

Table 5

Crosstabulation of Learning Style by Realistic Personality Type (n = 148)

	Realistic Personality Type	
Learning Style	*n*	%
Accommodating	56	37.8_a
Diverging	30	20.3_b
Converging	36	24.3_b
Assimilating	26	17.6_b
Total	148	100

$\chi2(3,N=148)=14.38$, $p < .002$.

Note. Percentages with no subscript in common differ at $p <.05$ using Holm's sequential bonferroni post hoc comparisons.

Conclusions and Discussion

The majority of the postsecondary automotive technology students who participated in this study had a predominant Realistic personality type resembling the O-Net (2007) classification. While disproportionate, the personality distributions did represent all six categories of Holland's classifications. Thus, the answer to the first research question is, Realistic is the predominant personality type of postsecondary automotive technology students (see Table 2).

The results of the Learning Style Inventory (LSI) were much more equally distributed than the personality classifications of the SDS. 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. Care should be taken by postsecondary automotive technology faculty within central Pennsylvania to differentiate instructional techniques to align with all four learning styles as 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. While past research studies have examined the relationship between personality type and learning style, few have focused on the trade and industry sector of CTE. Contributing to the void of research in this area, the calculated results of the Chi-square analysis (i.e., Table 5) within the study revealed a statistically significant relationship between the Realistic personality type and the Accommodating learning style ($p=.002$) of 56 participants or 31.8% of the overall sample of postsecondary automotive technology students. Thus, the answer to the second research question was: yes, there was a relationship between the postsecondary automotive technology student predominant personality type and their learning style. However, the relationship between personality and learning style was not observed outside of the 31.8% of participants with both a Realistic personality type and Accommodating learning style classification.

It is difficult to compare the results of this study to past personality and learning style correlation studies as they utilized different instrumentation such as the Myers - Briggs Type Indicator (MBTI) and Kolb's LSI (i.e., the modes of grasping experience dimension). However, the results of this study indirectly resemble past research on this topic in that a relationship was found between personality type and learning style. The results further identified a very unique sample of Realistic and Accommodating participants who had the ability to learn primarily from hands-on experience, would rather work with things than people and had an aversion to academic and therapeutic activities (Holland, 1997; Kolb & Kolb, 2005b) (see Figure 3).

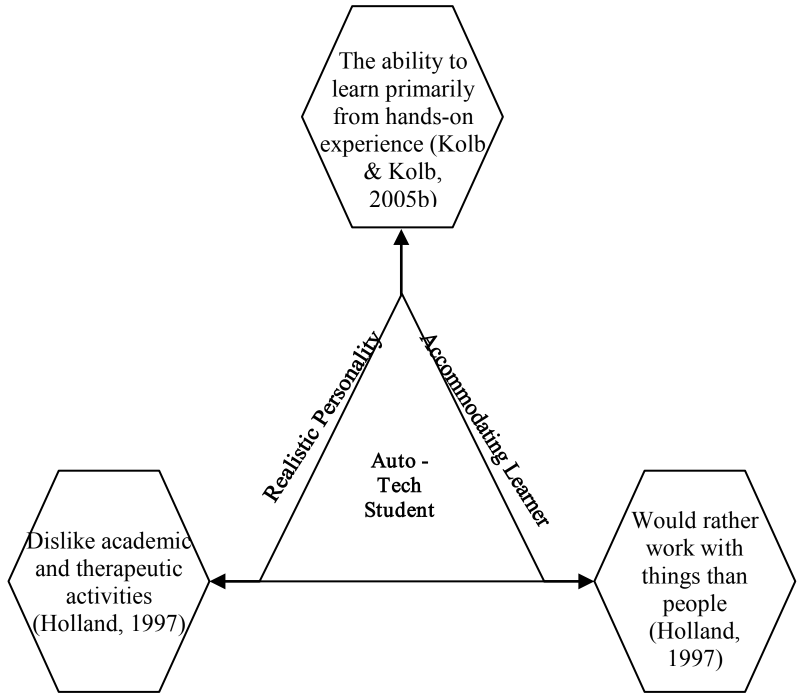

Figure 3. Characteristics of postsecondary automotive technology with an association between Realistic and Accommodating classifications.

Given the findings displayed within Figure 3, the educational specialization of automotive technology appears to be a natural fit. However, with these characteristics come some challenges within the automotive technology profession. For example, an automotive technician is expected to perform preventative maintenance and repairs on a daily basis within the automotive industry. If they would rather work with things than people, they may have a difficult time communicating effectively with a customer while attempting to pinpoint a vehicle drivability problem. Moreover, if they have an aversion to academic activities, they may find it difficult to write a handwritten description of a completed vehicle repair for billing purposes, put forth the effort to read a technical service bulletin (TSB), or calculate their completed flat rate hours to protect themselves from employer fraud.

These examples highlight standard operating procedures within the automotive technology field, which may conflict with the characteristics of 31.8% of participants. The Realistic and Accommodating learners will not, in most cases, search for opportunities to develop/learn these skill sets without assistance. Therefore, postsecondary automotive technology faculty within central Pennsylvania should supply these students with hands-on experience in occupational specific reading, writing and verbal communication (i.e., TSB reading, writing repair descriptions on work orders and customer communication role plays) including specific training on calculating and documenting completed flat rate hours.

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. A process of "adopting and adapting" instructional techniques and strategies for all learning styles seem more appropriate. 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. A process of adopting and adapting instructional techniques and strategies for all learning styles has the ability to enhance the educational experience for the student learners.

This process of adopting and adapting instructional techniques and activities can vary greatly depending on the area of educational specialization. Sample auto-tech activities are shown for each of Kolb's learning styles in Figure 4 to assist automotive technology faculty. A process of adopting and adapting instructional lesson plans to align with the sample activities/strategies may enhance the educational experience of all four types of learners within the automotive technology program (see Figure 4).

Accommodating	Diverging
Open-ended vehicle problems	Class discussions
Student presentations	Group lab projects
Hands-on repair simulations	Field trips
Converging	**Assimilating**
Vehicle computer simulations	Lectures/Presentations
Individual lab assignments	Repair manual reading
Field trips	Repair demonstrations

Figure 4. Sample activities of Kolb's learning styles for auto-tech faculty.

A cautionary note regarding the personality and learning style results of this study: there are no right or wrong classifications and everyone uses each learning style and personality type 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 and the SDS identified the strength of preference not the degree of personality and 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.

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A Calculus of Occupational Skill Attainment:
Building More Validity into a Valid Assessment System

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Abstract

This study investigated several aspects of occupational skill assessment as implemented in one state: (1) What is the extent to which student achievement on the cognitive component was related to their achievement on the psychomotor component of the technical skill assessments? (2) How efficiently was their overall composite attainment calculated? And (3) How well did this attainment predict student productivity on the job as determined by the employer's customer satisfaction? A sample of 118 student attainment scores on the written and performance components showed positive correlation. Further, this attainment was positively correlated with employers' customer satisfaction ratings. The panel of 16 national experts who participated in this study concluded that the Nedelsky (1974) method used to set the cut score needed to be re-evaluated. They also recommended that the scheme of calculation for determining one composite achievement level from the two test components should be modified.

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Introduction

The advent of the Carl D. Perkins Vocational and Technical Education Act of 1998, and the No Child Left Behind Act of 2001, ushered in a new era of educational accountability for career and technical education. With the passage of the Workforce Investment Act of 1998, states receiving Perkins funds were required to report to the United States Department of Education and the Department of Labor the extent to which these states were helping their students attain skills necessary for entry level employment and postsecondary education. States were also required to establish a system to report levels of student achievement of technical skills. While many approaches were available for reporting skill attainment, the Pennsylvania Department of Education (PDE) chose to utilize tests from the National Occupational Competency Testing Institute (NOCTI). These were occupationally specific, aligned to Classification of Instructional Programs (CIP) codes, developed in conjunction with industry, and were designed to measure entry-level job-ready attainment.

Career and Technical Education in Pennsylvania

The history of career and technical education in the state of Pennsylvania and the nation is a long one. By the mid-1880s vocational education in the form of industrial education was synonymous with institutional programs for youths. The children of defeated Native American leaders were sent to the Carlisle Pennsylvania Indian School, and the curriculum was job training (Clarke: Federal Education Policy & Off-Reservation Schools 1870-1933; a presentation of the Clarke Historical Library. Online at http://clarke.cmich.edu/indian/treatyeducation.htm). Both Vo-

Tech high schools and community colleges all across Pennsylvania received much support from federal funds. (Pennsylvania State Archives, RG-22 Records of the DEPARTMENT OF EDUCATION AGENCY HISTORY, from http://www.phmc.state.pa.us/bah/DAM/rg/rg22ahr.htm).

The focus of a national legislative movement was to properly equip secondary and postsecondary youths with the necessary tools that facilitate meeting the demands of emerging industries. If the United States is to remain at the forefront of the high-tech global marketplace, the workforce must possess the requisite technological competencies and academic skills (Education Encyclopedia, 2007). The legislative acts, popularly known as Perkins of 1984, Perkins II of 1990, Perkins III of 1998 and Perkins IV of 2006 further emphasized the new focus of career and technical education. Students who complete an approved career and technical education program are expected to be ready for postsecondary education and work.

> "The purpose of this Act is to develop more fully the academic and career and technical skills of secondary education students and postsecondary education students who elect to enroll in career and technical education programs, by-
>
> > (1) building on the efforts of States and localities to develop challenging academic and technical standards and to assist students in meeting such standards, including preparation for high skill, high wage, or high demand occupations in current or emerging professions;" (Carl D. Perkins Career and Technical Improvement Act of 2006, Sec. 2. (Purpose (1).

Part of the Act required eligible agencies to submit a Consolidated Annual Report (CAR) that included " Student attainment of career and technical skill proficiencies, including student achievement on technical assessments, that are aligned with industry-recognized standards, if available and appropriate" (113(b)(2)(A)(ii)). The assessments of occupational skill attainments are expected to meet the Perkins "Gold Standard." This is a reference to:

> a classification of technical skill assessments that the U.S. Department of Education, Office of Vocational and Adult Education, views as the most valid and reliable measurement of technical skill attainment. Specifically, the Gold Standard encompasses (1) technical skill assessments, developed by external, third-party agencies to assess national or state-identified standards (e.g., nationally validated employer/industry and postsecondary cluster standards); (2) national, state, or industry-developed credentialing or licensing exams, typically used to control entry into a profession; or (3) standardized statewide assessments of technical skills created by state administrators for local agency use (DTI Associates, 2007, p. 5).

The National Occupational Competency Testing Institute

Even before the passage of the Carl D. Perkins Vocational Act in 1963, Pennsylvania supported a loosely organized system of student occupational competency testing (Walter, 1984). With the Act, more students were enrolled in vocational programs that demanded a more organized system of assessing competency (Walter and Kapes, 2003). It was generally agreed that printing, distributing, administering, and scoring of examinations imposed an impractical burden on limited state resources. A consortium of 23 states ardently expressed that a third-party, nationally coordinated effort was needed to develop occupational competency examinations, in order for honest validation, establishing reliability, and other necessary construct measures. Most importantly, even the leading test development states were unable to experiment or carry on essential research, test development, field-testing, continuous revision, giving feedback to the states, and providing important test results and comparative, qualitative data. It was clear there was a need to professionally coordinate national efforts through a voluntary consortium effort (National Occupational Competency Testing Institute history online, from http://www.nocti.org/History.cfm). To that end, NOCTI became well established. Now NOCTI also owns a newly formed for-profit subsidiary, The Whitener Group, Inc., that provides a variety of assessment services for business and industry.

NOCTI has become a leading provider for occupational competency end-of-program assessments and services (NOCTI, 2007; Munyofu, 2007). By joining NOCTI, Pennsylvania gained the benefits of the national effort to produce quality occupational competency testing instruments to determine job-readiness among graduates of career and technical education programs. These tests were norm-referenced. Member states had the flexibility to choose how they interpreted the test results. Pennsylvania's initial choice was to identify students who performed at or above the national norm. These students were at that time considered as having distinguished themselves. They were awarded the governor's Pennsylvania Skill Certificate. Several unanswered questions remained. How did one know that an individual among the top half of those tested was good enough to be hired? (Munyofu, 2007, p. 4)

The Occupational Tests

The NOCTI tests are designed to measure both cognitive and psychomotor domains of career and technical education. The written component of approximately 200 multiple-choice items covers the entire program as outlined in the corresponding Classification of Instructional Programs (CIPs) of about 120 competencies. A written test may take approximately two to three hours. The performance component, on the other hand, consists of two to seven "jobs" which collectively address maybe 30 to 40 of the 120 competencies. This portion takes from three to four hours to complete.

The Performance (Psychomotor) Tests

Performance assessments consist of a series of tasks that make up a job. Individuals are required to complete jobs based on instructions provided in the test administration guidelines. Individual performance is rated by respective industry practitioner evaluators using specific criteria provided in the assessment's evaluator guide. The evaluator selects the rating that best defines the work being completed. Some tasks have five options (A-E). Others have a combination of options (A-C-E or A-E). The evaluator is only allowed to rate the individual with the ratings that are provided. Evaluator directions include the criteria for determining the process used and the results (product) achieved, including the value for each criteria based on a particular point scale.

In Computer Networking Fundamentals (excerpted from one of NOCTI's Technical Manual), for instance, the student might be required to:

> Create simple LAN with three PC's, using an Ethernet hub or switch and three straight-thru cables to connect

workstations. Select the appropriate cable(s). Connect cable(s) to Network Interface Card (NIC) and hub or switch. Configure the networks settings. Check network connectivity and demonstrate file sharing.

Configuring the network might be rated by:

A = Participant properly configures the IP address;
B = Participant properly configures 2 of the 3 settings;
C = Participant properly configures 1 of the 3 settings;
D = Participant properly locates the network settings;
E = Participant did not configure or locate the settings, or did not complete.

If the task is utilizing a 25-point scale, then A = 25, B = 20, C = 15, D = 10 and E = 5. On checking network connectivity, which is in a 10-point scale, A = 10, C = 6, E = 2. Connecting cables to Network Interface Cards is rated on a 5-point scale with A = 5 and E = 1.

The Standards

Pennsylvania Department of Education (PDE) reports student performance on these occupational assessments as advanced, competent, basic and below-basic with the following descriptions:

Advanced Level – This level reflects mastery of competence and understanding of academic/career and technical skills and knowledge required for advanced placement in employment and/or postsecondary education.

Competent Level – This level reflects a solid acquisition of academic/career and technical skills and knowledge required to enter employment and/or postsecondary education.

Basic Level – This level reflects an adequate attainment of academic/career and technical skills and knowledge required to enter employment or postsecondary education. Students with this score "would function at an entry level, but would require some assistance on the job."

Below Basic Level – This level reflects a partial acquisition of skills and knowledge needed to perform a given assignment, task or operation on the job. Additional instruction and/or assistance are necessary in order for the student to successfully complete specific assignments. Students with this score did not acquire the minimum skills "required for the occupation."

Setting Cut Scores: The Nedelsky Method

The Nedelsky (1954) method of setting cut scores is used only with multiple-choice tests. It requires an expert judgment about the distracter of each test item. The judge's task is to look at the question and identify the answers that a minimally competent test taker would be able to recognize as obviously wrong, before resorting to guessing on the remaining choices. Livingston and Zieky (1982) used the following example from a test of language skill. The test taker's task is to choose the word or phrase that best completes the sentence.

"My music teacher thinks that Marian Anderson sings_______any other contralto he has ever heard."

(A) more well than (B) better than (C) the best of (D) more better over.

A judge might decide that the borderline test taker would be able to eliminate wrong answers A and D.

> But the judge might decide that the choice between wrong answer C and the correct answer B is too difficult for the borderline test taker. The judge would then identify answers A and D as being so clearly wrong that the borderline test taker would be able to recognize them as wrong~~.~~ (p. 12).

When no choice is eliminated the candidate has a probability of guessing an answer correctly as 1 out of 4, hence *p*-value = 0.25. When 1 choice is eliminated, that probability is 1 in 3 or $p = 0.33$. Eliminating 2 choices leads to $p = 0.50$. When 3 choices are eliminated $p = 1.00$. The sum of the reciprocals over all the test items denoted the probable passing percent score for a single judge. The mean over all the judges is the percent cut score for the test.

For this method to provide valid and reliable results, the judges selected must be thoroughly knowledgeable about the subject matter for which the cut score is being developed. The panel must be sufficiently trained in this process so as to focus solely on the minimally competent candidate throughout the exercise. This training should include sufficient examples and discussion in order to increase inter-rater reliability.

Some researchers (Livingston and Zieky, 1982; Kapes and Welch, 1985) offered variations on the process, having compiled the judges' ratings. Some recommended using the median of the judges' ratings. Some suggested using a number halfway between the mean and median calculations. Others suggested eliminating the highest and the lowest score and calculating the mean of the remaining judges. Yet others allowed for adjusting the cut score using the mean minus a multiple of the estimated standard error of measurement ($S_E = s\sqrt{1-r_{xx}}$) where s is the standard deviation of the scores and r_{xx} is the reliability index.

Should the judges make their judgments individually or try to reach a consensus? The method seems to work fairly well either way, if the number of judges is not too large. But even with a small number of judges, it may take some time to get a consensus on each test question, and with more judges, it will be even harder to get them to agree. Yet, the judges can make more valid judgments if they share information and opinions with each other.

One limitation of this procedure is that it requires all the judges to make their judgments at the same time and place. Another limitation is that, even with the shortcut, it is fairly slow (though not nearly as slow as trying to get a group consensus on each question). For either of these reasons, some choose to have the judges make their judgments individually, without communicating with each other. The state of Pennsylvania went so far as to allow the subject matter experts to make their judgments online, after a thorough face-to-face training, practice and discussion.

Livingston and Zieky (1982) also addressed additional considerations on the process by which judgments are made:

> One important issue in the application of Nedelsky's method (and of Angoff's and Ebel's methods) is whether or not to tell the judges the correct answers to the test questions. Giving the judges the correct answers may make the questions seem easier than they are and, therefore, bias the judges in the direction of a higher cut score. If you do not give the judges the correct answers, they may judge some of the correct answers to be wrong answers that a borderline test taker would eliminate, but this information can be valuable. If several judges eliminate the correct answer to the same question, that question may be defective. And if one judge eliminates many of the correct answers, that judge may be unqualified.

> However, if you do not give the judges the correct answers, the judges may feel that they are being tested and may forget that their judgments are supposed to indicate the responses of a borderline test taker. In addition, the judging process will surely take longer if the judges have to take the extra step of figuring out the right answer to each question. A good solution, if your situation permits it, is to have the judges take the test before the judging session and then give them the correct answers to use while they are actually making their judgments. (p. 13).

Other cut score setting methods had been considered when Pennsylvania initially chose to establish criterion-referenced benchmarks. Walter and Kapes (2003) compared alternate methods of setting Pennsylvania's cut scores on the NOCTI assessments. They described how Nedelsky compared against Angoff (1971), Ebel (1972) and Jaeger (1982).

The Problem

The state of Pennsylvania's Department of Education, Bureau of Career and Technical Education, has stressed the importance of a skilled workforce that will meet the demands of the future. Graduates are expected not only to know about welding but also to demonstrate that knowledge by actually welding. They are expected to be ready not only for work but also for postsecondary and advanced education and training. Pennsylvania demands that a graduate's Certificate of Competency or Pennsylvania Skill Certificate be a credential that attests to knowledge and skills the employer expects.

While the state has maintained such a high standard, several issues about their assessment system needed to be examined. Do students perform equally well on the written and the performance components of the test? If they do not, apart from accounting for individual differences and learning styles, how does one calculate a composite overall student attainment? The system of determining the overall level of attainment has been recently criticized as being too severe. Some critics claim that Pennsylvania should put more weight on the practical component of the end-of-program tests than on the written. That way when a student is advanced on the performance and competent on the written portion of the test, that student should be considered advanced on the whole test. A student who is advanced on one part and basic on the other should be, at the minimum, competent. The other half of the conversation, interestingly enough, would like extra weight added to the written component! When preparing a test specification blueprint for Heating, Ventilation and Air Conditioning (HVAC) one participant disagreed with this, commenting that:

> As an industry person in HVAC (Heating, Ventilation and Air Conditioning), I see the emphasis on written tests as counter to my world. As we spoke, after I show a new person how do a task, I ask them to show me they can do it, not give them a pop quiz. We need a hands-on assessment task list. I believe that performance is 60%, the written is 40%. I understand that some may see the performance portion as subjective, but let me assure you that in my world that is far from the truth (participant at a session to create a test specification blueprint, 2008).

Even more important is the issue of predictive validity for the assessment. Although the assessments are constructed in conjunction with industry, and industry representatives actually evaluate students' performance on the hands-on component, no empirical study has been conducted to see if there is a relationship between assessment scores and on-the-job performance. Customer satisfaction assessment needs to be a hallmark of an effective career and technical education program. This study was undertaken to address the following questions related to student technical skill attainment:

1. Is there a relationship between student achievement on the written and the performance components of the tests?
2. Is there a relationship between students' achievement on the tests and their future performance on the job as measured by their supervisors?
3. Is the scheme of calculation used to create a composite attainment level from the written and performance components efficient and sound?
4. Is the Nedelsky (1954) method of setting cut scores as currently applied in Pennsylvania appropriate, efficient and useful for determining competency in occupational skill attainment?

Methodology

In order to determine predictive validity for the assessment system, a questionnaire (see Appendix) was prepared and sent to all career and technical education school directors in the state. They were asked to solicit customer satisfaction information about some of their graduates from the employers who were in a position to evaluate their on-the-job performance. The school representatives would then return the questionnaire with the desired information about their graduates. For each graduate they would indicate the graduate's achievement on the written and performance components of the test, whether the graduate is employed in an area related to the field of study, and the level of employer satisfaction indicated on an accompanying Likert scale. The returned questionnaires by 17 schools contained data on a sample of 118 currently employed graduates from career and technical education.

Three years of trend data for 2005, 2006, and 2007 (Tables 2 – 4) was assembled and analyzed to determine if there was a correlation between student attainment on the written and performance components of the tests. The four tables and background information were sent to a panel of 18 nationally recognized measurement authorities with a request to assist in improving the system of determining over-all student occupational skill attainment on the basis of written and performance scores:

- Should the performance component carry the same weight as the written component?
- How do you interpret the data in tables 2, 3 and 4?
- Is it necessary to modify the attainment calculus?
- Would you suggest how such a modification might be accomplished?

The Cut Scores

To determine a student's achievement on the performance component, fixed cut scores of 80%, 75% and 70% were established at the onset of this reporting system. This determination was made through consultation with career and technical education instructors, industry representatives, a test provider of occupational skill assessments, and a measurement consultant contracted for the assessment project (Kapes, 2001; Walter and Kapes, 2003). Also at that time there was no obvious objective method for setting a cut score for this type of assessment. The written component was routinely criterion-reference benchmarked by a team of industry practitioners using the Nedelsky method (1954). With the competent level thusly initially determined, the basic level was calculated by subtracting five (5) percentage points from the competent level. The advanced level was calculated as five (5) percentage points above the competent level. No adjustments are made to these cut scores utilizing the Standard Error of Measurement (SEM) or the introduction of actual student performance on the tests (Munyofu, 2008; Kapes & Welch, 1985; Walter & Kapes, 2003).

An over-all occupational skill performance on these end-of-program assessments is determined for the purpose of reporting on Perkins accountability indicators. The final attainment level is the lower of the two scores. The bivariate function is:

$$(1) \qquad f(x,y) = \begin{cases} x, x \le y \\ y, y < x \end{cases}$$

That calculus for determining an overall composite attainment is depicted in the chart below (Table 1). A student who had Advanced (A) on the written, and Basic (B) on the performance was Basic (B) on the overall attainment. A student who had Below-Basic (BB) on the written and Competent (C) on the performance was Below-Basic (BB) on the overall attainment. Table 1 shows the bivariate functioning.

Table 1. Occupational Attainment Calculus

f	Achievement on Performance			
Written	A	C	B	BB
A	A	C	B	BB
C	C	C	B	BB
B	B	B	B	BB
BB	BB	BB	BB	BB

Historical Data

Over the previous three testing cycles (Tables 2, 3 and 4), student performance on the two portions of the NOCTI tests followed the accompanying pattern. The total number in the table consists of only those students who took the complete test, having finished the written and performance components of the tests. Students omitted from the data took only the written component, only the performance component, or parts of each. Of all 9743 students (Table 1) who were Advanced on the performance component: 4994 were also Advanced on the written, 1285 were Competent on the written, 1892 were Basic on the written, and 1572 were Below-Basic on the written.

Table 2. 2007 Bivariate distributions of scores on the two components

	Achievement on the Performance Portion				
Written Achievement	A	C	B	BB	Total
A	4494	234	158	1364	6250
C	1285	89	64	382	1820
B	1892	184	134	777	2987
BB	1572	183	138	917	2810
Totals	9743	690	494	3440	13867

Table 3. 2006 Bivariate distributions of scores on the two components

	Achievement on the Performance Portion				
Written Achievement	A	C	B	BB	Total

A	5039	298	206	1687	7230
C	1314	123	94	547	2078
B	1864	244	150	950	3208
BB	1266	169	127	1254	2816
Totals	9483	834	577	4438	15332

Table 4. 2005 Bivariate distributions of scores on the two components

	Achievement on the Performance Portion				
Written Achievement	A	C	B	BB	Total
A	6060	436	309	1910	8714
C	1093	127	89	570	1879
B	1322	212	166	1133	2833
BB	741	133	134	1359	2367
Totals	9216	908	698	4972	15793

Results

An SPSS Crosstabs analysis of the customer satisfaction data is given in Table 5. The related Chi-Square tests are given in Table 6. The results indicated that there is a significant correlation between achievement on the written tests and achievement on the performance components of the tests $\chi^2(9, N = 118) = 76.246$, $p < .001$. Analyses were also conducted to determine the relationship between predictor variables (written and performance) and customer satisfaction. The analysis outputs are shown in Tables 7 – 10. Written correlation indices with Satisfaction (phi, Cramer's V, contingency coefficient) were statistically significant $\chi^2(9, N = 118) = 20.696$, $p = .014$. However the Performance indices were not statistically significant $\chi^2(9, N = 118) = 15.228$, $p =$

.085. The Written attainment is a better predictor of customer satisfaction after graduation than attainment on the Performance component.

Table 5. Attainment on the Written and Performance Tests

			Crosstabulation				
					P		
			1.00	2.00	3.00	4.00	Total
W	1.00	Count	6	0	3	10	19
		% within W	31.6%	.0%	15.8%	52.6%	100%
		% within P	66.7%	.0%	21.4%	11.4%	16.1%
		% of Total	5.1%	.0%	2.5%	8.5%	16.1%
	2.00	Count	1	5	0	6	12
		% within W	8.3%	41.7%	.0%	50.0%	100%
		% within P	11.1%	71.4%	.0%	6.8%	10.2%
		% of Total	.8%	4.2%	.0%	5.1%	10.2%
	3.00	Count	0	0	10	15	25
		% within W	.0%	.0%	40.0%	60.0%	100.0%
		% within P	.0%	.0%	71.4%	17.0%	21.2%
		% of Total	.0%	.0%	8.5%	12.7%	21.2%
	4.00	Count	2	2	1	57	62
		% within W	3.2%	3.2%	1.6%	91.9%	100.0%
		% within P	22.2%	28.6%	7.1%	64.8%	52.5%
		% of Total	1.7%	1.7%	.8%	48.3%	52.5%
Total		Count	9	7	14	88	118
		% within W	7.6%	5.9%	11.9%	74.6%	100%
		% within P	100.0%	100.0%	100.0%	100.0%	100%
		% of Total	7.6%	5.9%	11.9%	74.6%	100%

Table 6. Chi-Square Indices on Written and Performance Attainment

	Value	df	Asymp. Sig.(2-sided)
Pearson Chi-Square	76.246[a]	9	.000
Likelihood Ratio	58.435	9	.000
Linear-by-Linear Association	19.865	1	.000
N of Valid Cases	118		

a. 11 cells (68.8%) have expected count less than 5. The minimum expected count is .71

Table 7. Written Attainment and Customer Satisfaction

			Crosstabulation				
				Satisfaction			
			1.00	2.00	3.00	4.00	Total
W	1.00	Count	0	3	9	7	19
		% within W	.0%	15.8%	47.4%	36.8%	100%
		% within Satisf	.0%	50.0%	27.3%	9.1%	16.1%
		% of Total	.0%	2.5%	7.6%	5.9%	16.1%
	2.00	Count	0	1	3	8	12
		% within W	.0%	8.3%	25.0%	66.7%	100%
		% within Satisf	.0%	16.7%	9.1%	10.4%	10.2%
		% of Total	.0%	.8%	2.5%	6.8%	10.2%
	3.00	Count	0	1	11	13	25
		% within W	.0%	4.0%	44.0%	52.0%	100.%
		% within Satisf	.0%	16.7%	33.3%	16.9%	21.2%
		% of Total	.0%	.8%	9.3%	11.0%	21.2%
	4.00	Count	2	1	10	49	62
		% within W	3.2%	1.6%	16.1%	79.0%	100.%
		% within Satisf	100.0%	16.7%	30.3%	63.6%	52.5%
		% of Total	1.7%	.8%	8.5%	41.5%	52.5%
Total		Count	2	6	33	77	118
		% within W	1.7%	5.5%	28.0%	65.3%	100%
		% within Satisf	100.0%	100.0%	100.0%	100.0%	100%
		% of Total	1.7%	5.1%	28.0%	65.3%	100%

Table 8. Chi-Square Indices on Written Attainment and Customer Satisfaction

	Value	df	Asymp. Sig.(2-sided)
Pearson Chi-Square	20.696[a]	9	.014
Likelihood Ratio	20.570	9	.015
Linear-by-Linear Association	7.310	1	.007
N of Valid Cases	118		

a. 9 cells (56.3%) have expected count less than 5. The minimum expected count is .20

Table 9. Performance Attainment and Customer Satisfaction

			Crosstabulation				
			Satisfaction				
			1.00	2.00	3.00	4.00	Total
P	1.00	Count	1	1	3	4	9
		% within P	11.1%	11.1%	33.3%	44.4%	100%
		% within Satisf	50.0%	16.7%	9.1%	5.2%	7.6%
		% of Total	.8%	.8%	2.5%	3.4%	17.6
	2.00	Count	0	1	1	5	7
		% within P	.0%	14.3%	14.3%	71.4%	100%
		% within Satisf	.0%	16.7%	3.0%	6.5%	5.9%
		% of Total	.0%	.8%	.8%	4.2%	5.9%
	3.00	Count	0	0	8	6	14
		% within P	.0%	.0%	57.1%	42.9%	100.0%
		% within Satisf	.0%	.0%	24.2%	7.8%	11.9%
		% of Total	.0%	.0%	6.8%	5.1%	11.9%
	4.00	Count	1	4	21	62	88
		% within P	1.1%	4.5%	23.9%	70.5%	100.0%
		% within Satisf	50.0%	66.7%	63.6%	80.5%	74.6%
		% of Total	.8%	3.4%	17.8%	52.5%	74.6%
Total		Count	2	6	33	77	118
		% within P	1.7%	5.1%	28.0%	65.3%	100%
		% within Satisf	100.0%	100.0%	100.0%	100.0%	100%
		% of Total	1.7%	5.1%	28.0%	65.3%	100%

Table 10. Chi-Square Indices on Performance Attainment and Customer Satisfaction

	Value	df	Asymp. Sig.(2-sided)
Pearson Chi-Square	15.228[a]	9	.085
Likelihood Ratio	12.468	9	.188
Linear-by-Linear Association	4.594	1	.032
N of Valid Cases	118		

a. 12 cells (75.0%) have expected count less than 5. The minimum expected count is .12

Should the performance component carry the same weight as the written component?

There was little consistency in the responses of the consultants. Three respondents (# 3, 7 and 16) thought that both components should carry the same weight. They recognized a business and industry's point of view that the up-coming workforce needs to realize that there are fixed standards that must be met for the individual to be economically viable in the workplace. Respondent #16 noted that the two components measure similar competencies. "One assesses students' abilities to answer questions about the competencies, an important skill since students must be able to communicate about their work. The other assesses students' abilities to implement the competencies, also very important."

Six respondents (# 2, 4, 5, 8, 12 and 13) indicated that they would like to see something other than equal weighting. One (#5) suggested that the performance should count more; another (#8) preferred the written. A third (#2) recommended that no decision should be made without data: " On the measurement side: A component that predicts the criterion best should have the most weight. Often one component predicts better than another. Further, components that have low reliability will predict less well than others and they should be weighed less. On the policy side: you would have to defend the choice based on solid evidence from job analyses rather than personal preferences of the authorities." In order to implement a compensatory approach, individual tests should be analyzed. Respondent #13 stated it this way. "Though many would argue that all jobs require significantly better cognitive skills than they did 20 years ago, all jobs are not the same. Establishing an equal rating for all occupations between cognitive and performance scores does not account for differences in these technical occupations. If you use an arbitrary weighting of the 2 measures without tying it to workplace reality it would be an unrealistic measure."

The rest of the responses were "maybe," or "unsure," or were neutral. Respondent #15 stated that "many methods of scoring can be used. But, there seems to be a need here to give weights to both the theoretical test as well as the practical test." Some of these are described in response to the last question below.

How do you interpret Tables 2 – 4?

If the correlations are high, respondents said, it means that the scores are highly related. If they are highly related then it suggests that there is a lot of redundancy in the testing, so that two separate tests may not be necessary. That is not the case according to the crosstabs analysis results (Tables 13 and 14).

According to Tables 11 and 12, the largest group scored A & A the next largest group scored A & B! If the written test was too easy or had test security been compromised, then one should pay more attention to the performance results as being more valid because they were generated through observing students actually finishing a task. A second observation was that the written achievement had continued to fall---the BB level was proportionately larger in each succeeding year. However, performance scores had risen. A third item was that the Competent Written score group was the smallest size of the written achievement groups on each table. Along with this was the very low number of students who score in the Competent and Basic levels on the performance tests. The data suggested that most students either can do very well or very poorly, with few students scoring in the middle two sections on the performance tests. The overall percent of candidates rated as Proficient OR Advanced, inclusively, is not unusual for certification exams of this nature.

A respondent observed: "We see somewhat of a trend from 2005 to 2007 in terms of increasing "A"s on the performance test (58% to 62% to 68%), whereas you don't see that for the written (55% to 47% then steady at 47%). We also see a small trend indicating a decreasing number of people who get "A" on the written test but "BB" on the performance (12% to 11% to 9.5%), and an increasing number of people who get "A" on the performance test but "BB" on the written test (5% to 8% to 11%). Are teachers emphasizing hands on skills more but not the "academics" of the trade? Are evaluators trying to be more lenient in their scoring (e.g. not following the criteria as closely as they should)?

Table 11 Achievement Distribution over three years

Written and Performance Achievement percentage distribution of students		
2007	Written	Performance
A	0.47	0.68
C	0.13	0.05
B	0.21	0.03
BB	0.20	0.24
2006	Written	Performance
A	0.47	0.62
C	0.14	0.05
B	0.21	0.04
BB	0.18	0.29
2005	Written	Performance
A	0.55	0.58
C	0.12	0.06
B	0.18	0.04
BB	0.15	0.31

The statistical relationship between student performance level based on written and the practical performance evaluation was examined in analysis of the 2007 data. The results are presented in Tables 12, 13 and 14. Noteworthy is the rather low relationship between these two measures as indicated by the indices of association shown in Table 14.

Table 12. Attainment on the Written and Performance Tests for 2007

Crosstabulation

Written Test (PLW)			Performance Test (PLP) 1.0	2.0	3.0	4.0	Total
	1.0	Count	4494	234	158	1364	6250
		% within PLW	71.9%	3.7%	2.5%	21.8%	100%
		% within PLP	48.6%	33.9%	32.0%	39.7%	45.1%
		% of Total	32.4%	1.7%	1.1%	9.8%	45.1%
	2.0	Count	1285	89	64	382	1820
		% within PLW	70.6%	4.9%	3.5%	21.0%	100%
		% within PLP	13.9%	12.9%	13.0%	11.1%	13.1%
		% of Total	9.3%	.6%	.5%	2.8%	13.1%
	3.0	Count	1892	184	134	777	2987
		% within PLW	63.3%	6.2%	4.5%	26.0%	100.0%
		% within PLP	20.5%	26.7%	27.1%	22.6%	21.5%
		% of Total	13.6%	1.3%	1.0%	5.6%	21.5%
	4.0	Count	1572	183	138	917	2810
		% within PLW	55.9%	6.5%	4.9%	732.6	100.0%
		% within PLP	17.0%	26.5%	27.9%	26.7%	20.3%
		% of Total	11.3%	1.3%	1.0%	6.6%	20.3%
Total		Count	9243	690	494	3440	13867
		% within PLW	66.7%	5.0%	3.6%	24.8%	100%
		% within PLP	100.0%	100.0%	100.0%	100.0%	100%
		% of Total	66.7%	5.0%	3.6%	24.8%	100%

Table 13. Chi-Square Indices on Written and Performance Attainment

	Value	df	Asymp. Sig.(2-sided)
Pearson Chi-Square	268.760[a]	9	.000
Likelihood Ratio	266.199	9	.000
Linear-by-Linear Association	188.936	1	.000
N of Valid Cases	13867		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 64.84

Table 14. Written and Performance Correlation Indices

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Phi	.139			.000
	Cramer's V	.080			.000
	Contingency Coefficient	.138			.000
Interval by Interval	Pearson's R	.117	.009	13.839	.000[c]
Ordinal by Ordinal	Spearman Correlation	.122	.009	14.425	.000[c]
Measure of Agreement	Kappa	.065	.005	13.188	.000
N of Valid Cases		13867			

a. Not assuming the null Hypothesis
b. Using the asymptotic standard error assuming the null hypothesis
c. Based on Normal approximation

Is it necessary to modify the attainment calculus?

Based on the information provided, many of the participating experts were of the opinion that the calculus used to determine final skill attainment (Formula 1 and Table 1) was too stringent. "It seems to me," one expert (#2) stated, "that the procedure you are currently using for deciding who will pass is very arbitrary and should be studied in terms of how well people do on the job after taking the test or how well employers perceive these people are doing." In other words, doing a validity study using real job criteria. If you discover, for example that many people who do poorly on the real job receive "C" or better on your performance assessment, you would have evidence that your assessment is not valid." Expert #5 opined, "I do think the attainment calculus needs be modified. In particular I find the number of a/bb students unacceptable as such a discrepancy suggest to me the written assessment is measuring unrelated academic skills."

One respondent (#7) thought that there was no need to modify the attainment scheme. Another (#10), who chose not to commit one way or the other, commented that "The bottom line is that, you want the results to reflect your political objectives but I would not lower the percent from the written portion below what you already have." This was somewhat supported by #13, "The answer to this question really depends on the goal one is trying to achieve. However, we would recommend drilling down to at least the cluster level before making any kind of change in weighting. CTE's strength is in its connection to the workplace, so it is critical to maintain a metric that reflects that strength. One might compare what a change might do (if implemented) across the different clusters. Would it equate to more "A"'s in one group and less in another?"

How would you suggest such a modification be accomplished?

Many thought that the question was more political than not. They preferred to address cut score issues in the hope that the composite achievement problem will be indirectly resolved. One respondent offered the following refinement. " I would average the two levels and always round the results downward. So, some portions of the original Performance Calculus table would stay the same (e.g., A-A =A; A-C =C; C-B = B; B-BB = BB). And, others would change (e.g., A-B = C; C-BB = B; A-BB = B)." (See Tables 15 and 16.) The bivariate function would be

$$(2) \qquad f(x, y) = \left\lceil \frac{x+y}{2} \right\rceil .$$

If Advanced = 4, Competent = 3, Basic = 2 and Below Basic = 1, then the function would be given by the chart below (Table 15).

Table 15. Modified Achievement Calculus

f	Achievement on Performance			
Written	4	3	2	1
4	4	3	3	2
3	3	3	2	2
2	3	2	2	1
1	2	2	1	1

Table 16. Modified Achievement Calculus

f	Achievement on Performance			
Written	A	C	B	BB
A	A	C	C	B
C	C	C	B	B
B	C	B	B	BB
BB	B	B	BB	BB

The calculation scheme proposed utilizes a form of compensation that would serve to safeguard against measurement errors, i.e. false negatives. The calculation would increase the proportion of students deemed at least Competent, a measure that would present the state's federal accountability results into a better light. Finally it would considerably reduce the proportion of students who are Below Basic.

Discussion

The results of this study indicate that there are serious issues that must be resolved before the student occupational skill assessment system in Pennsylvania can claim validity. This observation is in spite of the well-established credibility of the NOCTI Job-Ready assessments. It was commendable when Pennsylvania moved away from using the national norm as the standard for awarding the Pennsylvania Skills Certificate. They chose a criterion-referenced benchmarking model to determine whether a student who completed a career and technical education program was indeed ready for employment or postsecondary education.

When additional needs for information from the tests arose, the Pennsylvania assessment system did not evolve to accommodate these additional needs. These needs included: (1) benchmarks for the Advanced level in recognition of students who had distinguished themselves enough to be eligible for the Pennsylvania Skills Certificate; (2) criterion-referenced benchmarks for the Performance component of the tests; (3) benchmarks for the Basic level for those graduates who were employable, albeit needing additional training and remediation; and (4) evaluating the efficiency of determining overall student attainment.

The experts consulted in this study recognized that first and foremost, the benchmarking method needed to be updated. The Bookmark method (developed by CTB/McGraw-Hill, 1996) was suggested as the most appropriate for setting the three cut scores at the same time and applicable for both the written and performance components of the tests. "In general, the strengths of the Bookmark method are that it (a) accommodates constructed-response as well as selected-response test items; (b) efficiently accommodates multiple cut-scores and multiple test forms; and (c) reduces cognitive complexity for panelists" (Lin, 2006).

Other consultants suggested that Pennsylvania consider the Body Of Work model for setting the cut scores, as that method has been utilized for the Pennsylvania System of School Assessment (PSSA). However this would only be feasible for the written component. The performance (practical or hands-on) component focuses on the process as well as the completion of the assigned task. At this time neither Pennsylvania nor NOCTI has a system to preserve the body of work produced by the student. Yet it would be useful for test providers to consider investing in simulation programs to facilitate the assessments and preserve the testing process as well as the finished product.

NOCTI in 2008 started establishing national cut scores on their tests following the Pennsylvania model but with several modifications: (a) While in Pennsylvania the training of judges was conducted in a face-to-face format, the national training was conducted exclusively online. (b) Actual implementation of the judges' scoring was web based. (c) For each item the correct answer was already identified, so that the judges only needed to look at the item distracters and indicate which were obviously incorrect in the view of a minimally competent candidate. Of course this modification has the potential of tending towards higher cut scores (Livingston and Zeiky, 1982). (d) The highest and lowest judgments were dropped. Also dropped were judges who appeared not to follow the instructions correctly, in the opinion of NOCTI. (e) The Competent level was determined as the mean score for all the judges on the entire test, minus one standard error of measurement. The result was the percent of the items that must be answered correctly for a student to attain the Competent level. Although NOCTI considered this adjustment as a means to establish more defensible cut scores, no empirical basis was offered. (f) The Basic level was 10 percentage points lower than the Competent level. The Advanced level was 10 percentage points above the Competent level. Again, the use of an arbitrary calculated range of ± 10 was not justified. These modifications did not adequately address the concerns raised by the experts consulted in this study.

The first significant recommendation was that the state adopt a more up-to-date method for setting the cut scores. The second significant recommendation was that the calculus for determining overall attainment be modified in order to reduce the impact of possible false negatives. Often school administrators and career and technical education teachers advocate on behalf of some form of adjustment when a student achieved a much higher score on one form of the test than on the other. If the two scores cannot be reported separately then a variation of averaging the two scores appears to address that concern.

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APPENDIX

Customer Satisfaction Survey

BCTE is interested in the extent to which student performance on occupational end-of-program tests is related to on-the-job performance. This is a part of an investigation about how accurately test cut scores help to predict success after graduation. The bureau will be able to modify how the cut scores are determined and consequently how student achievement will be used to evaluate career and technical education programs.

Please identify at most 8 of your former graduates who are employed and whose supervisor can provide you an evaluation of their job satisfaction. Then fill the table below with the student achievement on the written and performance portions of the NOCTI test. Please return this to me before September 30, 2008.

School:								
Student	**Employment**	**Test Results**		**Employer Satisfaction**				
Number	**Employed/ Related**	**Written**	**Performance**	**5**	**4**	**3**	**2**	**1**
0 example	Yes	C	A		√			
1								
2								
3								
4								
5								
6								
7								
8								

List students as 1, 2, 3, etc and no student names.

Is the student employed in a field related to the program completed? Indicate yes or no in this column.

What was the student's occupational achievement on the end-of-program tests, both written and performance?
A=Advanced, C=Competent, B=Basic, BB=Below Basic.

From the student's employer supervisor, please indicate the level of <u>technical expertise</u> demonstrated by the student on the job. Use 5=Very satisfied; 4=Somewhat satisfied; 3=Neutral; 2=Somewhat dissatisfied; 1=Not satisfied.

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Build Your Own Electric Vehicle
By Seth Leitman and Bob Brandt
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In their book *Build Your Own Electric Vehicle* Seth Leitman and Bob Brandt provide interesting bits of electric automotive history and it could not come at a better time. A sample of the history provided by the authors was Henry Ford's motor company that manufactured over 15 million Model T automobiles between 1908 and 1927 (Henry Ford, n.d.). These vehicles were noisy and powered by a small, internal combustion (IC) engine. Interestingly, his wife, Clara Bryant Ford, was the owner of a 1915 Detroit Electric vehicle powered by a quiet electric motor that managed 25 miles per hour with a range of 80 miles per charge.

The crux of this book is not about building an electric vehicle (EV) from scratch, rather it's about converting a used pickup or a small economy car with an (IC) engine to a plug-in EV. The result of this conversion would be a vehicle that would get you around town and home again with zero emissions. The authors provide several illustrations of vehicles that have been converted, these include: a 959 Porsche, a GMC van, a Chevy S-10 pickup, and even a Rolls Royce. The authors stated that the prime candidate for this type of conversion is a short wheel base pickup truck that can handle the added battery weight needed by an EV.

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Overview

In Chapter 1, entitled *Why Electric Vehicles are Still Right for Today!* the authors dispel some myths about the shortcomings of an EV. A primary concern for anyone who owns a EV is the range. General Motors conducted a study in the early 90's that indicated that 8 percent of all trips driven are 25 miles or less. A federal government report indicted that the average daily commuter trip was only 10 miles. Leitman and Brandt stated that many of today's 120-volt electric vehicle conversions will go 75 miles or more before charging is required.

Why should you convert an IC vehicle to electric? According to the authors, EVs are cleaner, more efficient, and a very effective form of transportation. The first chapter also provides an interesting comparison of the operating costs of an EV versus an IC. There are several variables to consider when making a comparison, IC mpg, price per gallon of gasoline and monthly consumables for repair and maintenance. An important variable for the EV is the cost of kilowatt-hours (kwh). The authors compare an IC vehicle that averages 20 mpg at $4.50 per gallon to an EV that uses $.165 kwh (the rate for New York) multiplied by .44kwh (the mileage for a converted Ford Ranger pickup). At these rates, the EV wins hands down at 7.3 cents per mile to 27 cents per mile. This includes the addition of consumables like oil and filters plus periodic costs for maintenance at 4.2 cents per mile, based on $500 per year at 12,000 miles for both vehicles. For this example, the IC is favored slightly because the EV will have lower maintenance costs due to not requiring oil changes, filters, etc. In any event, energy efficiency is a critical component of this argument. If you change the gas price to the current cost in the Midwest ($2.25) and increase the gas mileage based upon a good hybrid gas-electric (40 mpg) the economy of the IC changes significantly to about 9.8 cents per mile including consumables.

Going Green

The green effects of an EV are highlighted in Chapter 2, *Electric Vehicles Save the Environment,* especially when compared to an IC. This chapter includes many concerns regarding ICs, including dependence on foreign oil, the greenhouse effect, toxic air pollution, and wasted heat. What would be the effect of thousands (or maybe millions) of electric vehicles on the roads? A shift to large numbers of electric vehicles does demand more from coal-fired generating plants. However these coal generation stations have advantages in that they can be controlled more than internal combustion vehicles. An interesting note about this chapter is the author's argument that conversion to EVs will provide an economic benefit to our electric utilities because it will represent a new market for electricity sales.

A Rich History

The story of the electric vehicle during the 20th century could be described to a certain extent, as on again and then off again, at least in terms of normal passenger vehicles. Chapter 3, *Electric Vehicle History* is packed with interesting facts and figures regarding all types of EVs. For example, "Electric vehicles enjoyed rapid growth and popularity until about 1910, then a slow decline until their brief resurgence in the 1990s" (p34). The authors show four waves of EV development in the United States, Europe, and Japan. The first wave came in the 1960s, the second after 1973, the third after 1979 and the fourth in the 1990s. Great Britain led EV development with electric milk trucks totaling more than "100,000" vehicles (p44). In the 1970s the United States Postal Service made use of "350" electric vans purchased from AMC General Corp. (p48). Have you ever run across a Dodge Omni that was converted to an EV? If so, this conversion was completed by Jet Industries of Austin, Texas in the 1980s. These vehicles "are prized possessions among Electric Auto Association members today, attesting to their outstanding quality and durability" (p. 52). In the 1990s, General Motors gave us the famous, or maybe, infamous EV1. This vehicle, which was the subject of a documentary (*Who Killed the Electric Car?),* is an example of Detroit mentality that was two steps forward and three steps backward. They built 50 of these vehicles which had to be returned to the dealers after being leased to customers. Ultimately, GM crushed them in the Arizona Desert for a number of reasons explained in the film. Ironically, this vehicle had an impressive set of stats including "a 0.19 coefficient of drag (still the most aerodynamic production car ever made)," a "50 to 70 mile range" that could be extended to "120-140 miles" with nickel metal hydride (NiMH) batteries, "a 0-to-60 time under 8 seconds" and an "80-mph freeway capability" (p.62).

The Nuts and Bolts of a Conversion

The remainder of this book is essentially the details about how to go about a conversion and your best choice in components and batteries. If for example, you take an early 90s Toyota Celica and want to convert it to an EV, you will need a vehicle that has a manual transmission. Manual transmissions are preferred and explained in Chapter 5, *Chassis and Design.* The best choice in electric motors are detailed in Chapter 6 which provides a range of alternatives. The authors say "the series DC motor is unquestionably the best for today's first-time EV converter," however, "Improvements in solid-state AC controller technology clearly put AC motors on the fast track for EV conversions of the future" (p. 155).

Another essential component is the motor controller which is covered in Chapter 7. Controller efficiency includes building or buying the best controllers on the market. The heart of an EV conversion is in the batteries which are covered in Chapter 8. The authors detail batteries in regard to how they work, charging considerations, and vanities. According to the authors, the Trojan battery company of Santa Fe Springs, California, provides the best performance as well as cost in lead-acid deep cycle batteries.

Chapter 9 covers the charging and electrical systems, as well as details on step by step conversion of an IC vehicle. Chapter 11 provides the particular skills needed to drive an EV vehicle, licensing, insurance and car care. Finally, Chapter 12 provides a number of vendors that supply the best products and prices.

Conclusion

The authors provide a cost list to make an EV conversion that provides several different scenarios for the buyer. Using an economy car with a combination of new and used components, the total cost is estimated at $5,200. This is a rock bottom cost for a do-it-yourself project. Obviously, using a newer vehicle with new components and having it converted by someone else will increase the cost of such a project. At the high end, the estimate can reach $17,500. In any event, this type of conversion project makes sense, especially for a second vehicle that is used around town. Moreover, the conversion of an IC vehicle to an EV is a move towards more appropriate technology, technology that is environmentally as well as user friendly. Is such a conversion project beyond the scope of a high school or post-secondary technology education program? Some schools have done it as demonstrated by the Technology Studies Department at Fort Hays State University in Kansas. They have their own EV pickup that was converted by faculty and students 9 years ago. The expenses for this conversion were supported by a Department of Transportation *Clean Cities* grant.

Build Your Own Electric by Seth Leithman and Bob Brandt is an excellent guide and starting point for such a project.

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Unlearning How I Have Been Taught

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The readership of the Journal of Industrial Teacher Education includes instructors and professors who prepare professionals in the fields of industrial and technical teacher education and industrial and military training. My hunch is that more than a few times these career and technical teacher educators have said to their students, "OK, let's break into small discussion groups." Although it may not have been apparent to the naked eye, several of these students may have internally cringed at the idea of working in another small group. The purpose of this brief essay is to help career and technical teacher educators think about these group learning experiences from the eyes of their students. Perhaps my story as a learner can lend insight into helping these students learn how to learn in any setting – including group activities.

I am a graduate student in a program that emphasizes science and technology. For as long as I can remember, I have always disliked group activities. I rarely learned much from such activities let alone retained anything that I may have learned. On the first day of a recent class, my spirits dropped when the professor announced that the class would be doing several group activities throughout the semester. Not again, I thought to myself. As class proceeded, I listened to the professor explain how students need to analyze their reactions to their least preferred ways of learning. According to Pavlovich, Collins, and Jones (2009) incorporating the emotional experience into a reflective process may help students better examine how they think and feel about situations. It took me a while to break down my biases about group activities. As seriously and objectively as I could, I slowly began to understand my feelings of dislike for group activities.

My academic background has always revolved around science courses that prepared me to learn in a certain way and in a specific type of environment. As a child, I attended a private school. The students were competitive because they all wanted to make the honor roll. Thus, many of these students evolved into highly motivated self-directed learners. If the students did not understand the material taught in class, they were expected to either stay after school for extra help or review the material at home. Group activities rarely occurred. The classes were very structured and the majority of the learning was dependent on the teacher. Once students reached fifth grade, twice a year, they picked science projects to conduct. The science projects were entirely self-directed learning projects with deadlines to turn in writing assignments or data to the teacher.

In college, I majored in a science area. I had to individually read and learn things on my own under the guidance of the professor(s). I conducted laboratory exercises testing particular theories. Group projects or activities were rarely needed for these classes. My learning environments were always quiet areas with few distractions. Nearly everything that I learned in my undergraduate studies occurred in a theory and laboratory format. My current learning style is that of learning about ideas in a logical manner that allows me to play with the ideas in my own way.

I have come to realize that my professors' teaching methods have greatly influenced my learning preference and style. Looking back at my educational settings and formats, I have always been taught in classes that were structured, quiet, and individualistic. I know that I need to be in a quiet environment without distractions so that I can clearly hear my thoughts about things. I need to be left alone to my thoughts or readings in order for me to learn and understand concepts and ideas. Also, I had always perceived group work to be the complete opposite of my learning style because it is not in a structured format and does not give me the opportunity to process my thoughts or ideas at my own pace.

I began to challenge my biases towards group activities. Slowly, I deconstructed my group bias and discovered that maybe it has been a misconception that I constructed over time. I reaffirmed to myself throughout the years that learning in conditions other than my training and my preferences was not effective and a waste of my valuable time. After taking a long hard look at myself, I think the truth of the issue is a resistance to change. I became accustomed to my routine of learning and was unwilling to accept the chaos of group activity. I had not recognized the importance of learning in ways or conditions that were different from my preferences.

Palmer alluded to this penchant for building a comfort zone and hunkering down in it, "we often clutter our learning space with obstacles and distractions to evade the emotions that education evokes" (p. 83).

I recently completed a graduate course on learning how to learn. This experiential learning course was a huge stretch for me. As a result, the self-imposed boundaries to my thinking were pushed out and I came to realize that my beliefs about learning need to change. There are many things that I do not know, especially about myself. The experience has helped me to envision a future for myself in which I am a lifelong learner. I want to be able to effectively use the knowledge I gain from collaborative learning activities. I want to evolve into a better learner -- a person who can learn from any type of activity or situation and apply that knowledge to my life. Furthermore, I realize I must unlearn how I have been taught.

Perhaps my journey as a learner can provide insights to you – the readers of JITE. Students arrive in your classrooms with predispositions regarding various types of learning activities and conditions. They have preferred approaches to learning, and they also may try to avoid some learning situations like the plague (Roth, 1997). Help these students come to know themselves as learners. The odds are they have never critically analyzed themselves as learners even though they have many years of formal education. Within your class sessions integrate discussions and activities, allow them to focus on themselves as learners. They need to understand how they have evolved as learners, and how they can become more effective and efficient as learners regardless of the context (Smith, 1982). Give these students a gift that will last a lifetime-- help them develop skills in learning how to learn.

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Students Must Understand Both Theory and Practice in Engineering/Technology Education

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The name of our profession has gone through many name changes throughout the years. From "Manual Training" to "Industrial Arts" to "Industrial Technology," the names have changed, but the goals have always been the same: to teach students how to become more technologically literate in an ever-changing world, while gaining skills that will help them to become productive citizens in this changing world. The inclusion of pre-engineering education in K-12 technology education programs has become more prevalent in the last decade because of the shortage of qualified students who graduate with engineering and engineering technology degrees (PLTW, 2007). This is now leading many state curriculums and university programs to begin using the name "Engineering/Technology Education" in reference to their technology education programs. In a recent International Technology Education Association (ITEA) poll, 30% of 829 technology education-related responders said that their teaching field in their state has either changed names in the last two years, or was contemplating changing its name in the near future (ITEA, 2008). The U.S. Department of Labor predicts that the global economy will be short 15 million technical workers by 2020 (Opsahl, 2006). It is the job of high school technology programs to help prepare students for successful college experiences in engineering and engineering technology.

Pre-engineering education involves coursework in subjects that draw content from the work of engineers and promises engineering and technology careers as potential futures of the students who pursue these courses (Lewis, 2004). Including pre-engineering courses in current technology education programs gives students a small taste of many of the possible problems, situations, and case studies that many engineers encounter every day. Pre-engineering courses should address technical content from a design and modeling approach, where engineering analysis is an important element along with string connections to mathematics and science (Burghardt, 2006). Teaching pre-engineering content in this way may differ from what may be seen in traditional Technology Education programs. Many Engineering/Technology Education educators could find themselves concentrating on teaching all their students the theories behind technology education, and not giving them adequate career skill immersion. Some could find themselves trying to create future engineers, while forgetting about those students who aren't interested in careers in technology or engineering. Engineering/Technology Education programs and teachers must remember to incorporate the theory behind E/TE to all their students to help them become more technologically literate, but also let them get hands-on practice that will help those with the propensity to excel in the engineering or engineering technology fields.

Understanding Engineering/Technology Education Theory

Technological Literacy can be described as the history of technology in society, the positive and negative impacts of it, and the discussion of technology from a basic "how it works" perspective (ITEA, 2000/2002). Engineering/Technology Education's role in our schools is to prepare students to be technology literate for our technological society by understanding the *need* to be technologically literate, since technology will always be a part of all aspects our lives including education, home, health, career, and community. Students should also begin developing an understanding for experiences with problem solving skills, and begin to integrate the core subjects of math, science, language arts, social studies, physical education, and art knowledge and skills together. It is imperative that new K-12 pre-engineering programs include these important concepts as a part of their every day offerings, because in many cases, students are either taking these courses in lieu of the traditional technology education courses offered at their school, or schools have replaced those traditional courses with pre-engineering courses (Lewis, 2004). It is the responsibility of the instructors and the schools to provide these students with the technological literacy they need in their pre-engineering courses, even if they are not going to pursue engineering as a future career. Technology education is for all students. Technological literacy should be understood as the ability to use, manage, understand, and evaluate all technology, not just "engineering technology." These students who decide that engineering is not for them must still be given the opportunities to engage in the basic theory behind Engineering/Technology Education, and that is to learn about and experience technological literacy to become more productive citizens.

Engineering/Technology Educators need to model the basic technology skills that many others may take for granted that students already know. Visual communication skills, such as sketching, basic prototyping using construction and/or manufacturing skills, power and energy knowledge, and fundamental computer skills are extremely important concepts which all students should be exposed to, and in many cases it falls into the hands of the high school engineering/technology education instructor to either teach these skills, or help expand on the rudimentary skills the students have already learned in middle school. Successful engineering/technology education requires a fundamental understanding of technology, and the impact it has had on our society. Having students who have had previous courses in technology, and are familiar with many of the terms and situations the instructor is expanding on only makes the E/TE educator's job easier. If they are lacking in those skills, it becomes the job of the E/TE instructor to show students the technology theories and concepts they need, because it is their job to prepare all students for their submersion into an ever-changing world, regardless of what career path they choose to take.

Understanding Engineering/Technology Education Practice

For those students who are taking Engineering/Technology Education courses as a pathway to engineering or engineering technology careers, acquiring technological literacy, while important, may not be enough to satisfy their desire for specific skills they will want for university work. This is where the practical side of E/TE can become very important to many students. Engineering education differs from technology education in the inclusion of engineering analysis. Engineers want to develop physical models, and then create mathematical models that describe these physical models (Burghardt, 2006). Students who plan to go to higher education to study engineering should have this experience in analysis, amongst the engineering career concepts they encounter, so they are more familiar with it before their entrance into a university setting. *Project Lead The Way Principles of Engineering* instructor D. Martin (personal communication, 3/26/08) of Hobart High School in Indiana, states:

> In past courses, I have had many projects where "building and testing" the models made were the only modeling approaches used for successful project completion. Many student trial-and-error sessions were sometimes required. Usually, no "engineering" went into the designing of solutions. Now, in my Principles of Engineering course, we use computer-based mathematical modeling, which has opened up new areas of project success. While doing essentially the same project, students are now using mathematical formulas and design software, where math and modeling are now playing a huge role in the initial design process. Students are now able to predict the behavior of their design and understand the factors that ultimately positively or negatively affect the performance of their design.

Students participating in pre-engineering coursework come to see what being an engineering technologist entails. As John Runkle and Calvin Woodward pushed the concept of students gaining career skills through manual training in our country in the late 19^{th} and early 20^{th} centuries, pre-engineering programs are now trying to also push the concept of students gaining career skills in engineering-related fields at an early age. In the *Project Lead the Way* model of pre-engineering courses, *Principles of Engineering* is a course where students can explore engineering as a career, understand what engineers actually do, and see how they use science and math every day effectively (Lewis, 2004). The *Engineering by Design (EbD)* course *Engineering Design*, the capstone course for the International Technology Education Association (ITEA) curriculum, incorporates many of the actual experiences that engineers encounter. Capstone *EbD* students are challenged to participate as members of engineering teams within a typical business organization, while work completed will be reflective of authentic engineering projects found in the designed world (ITEA, 2007). E/TE students should be held to high accountability, just as practicing engineers are. E/TE classrooms should be organized, civil areas of learning and work-based simulation; as true to life as the school and instructor can make it within the educational environment's limitations. Work-based simulations can entail presentations, group work, deadlines, etc. – all important concepts for any class, but in this case, tailored to an engineering environment. Students who can successfully experience this type of work-based simulation can gain many positive experiences that can propel them into positive college engineering experiences. These college experiences are positive because in many cases, the students will have seen some of the curriculum before, only introduced and simplified for ease of understanding.

Incorporating Both Engineering/Technology Education Theory and Practice

In the *Standards for Technology Literacy* (ITEA, 2000/2002), the national standards created by the ITEA from 1994-2004, the content for technological literacy closely aligns with the content used by engineers. For example, in the teaching of Standard 9, *Engineering Design*, and Standard 11, *Apply Design Processes*, students can actually experience the procedures real engineers use to design products and systems. The *Project Lead the Way* curriculum is based upon the national standards for Science, Math, English and Technology Education (PLTW, 2006). The writers of these standards and curriculum understood the important role the pre-engineering education would have on the future of technology education. Teaching pre-engineering concepts and giving students real-world engineering situations to learn from are learning experiences many experienced technology educators may not have used in their classrooms. By solely putting the teaching of their students' technology literacy in the foreground, while placing the teaching of specific career skills in the background, some teachers may have put some students at a disadvantage when they began their university training.

Engineering/Technology Educators must present students with both theory and practice. On any given day, however, either may become more important than the other. When students are lacking in a particular concept area in terms of knowing something "technologically," it is important for the instructor to perhaps stop the engineering lesson and go back to teach some technology concept that multiple students didn't pick up on in the past, or set aside extra time for these students to remediate in that area. Many other days, instructors are covering engineering concepts, presenting experiences and case studies, and letting students involve themselves in projects that mimic (with limitations) what many engineers go through in their daily routines. This is the reason why many of the students in pre-engineering courses took them as electives – to see if a future career in engineering is right for them. They may only find these specific career skills in the E/TE classroom, and it is the instructor's job to try to the best of their ability to satisfy that curiosity.

Conclusion

A balance between when to teach theory and when to let students experience practice needs to be attained in the E/TE classroom. This balance can be achieved through vigilance and observation by the E/TE instructor. The instructor's main job should be to ensure technological literacy for all in the classroom. The students need to become technologically literate for today and tomorrow's world, no matter what career pathway they choose to take. Helping develop career skills through pre-engineering practice should not automatically be the first priority until technology literacy theories are mastered first. Getting to know one's students closely, understanding their strong points and limitations, and sensing their levels of interest can help the E/TE educator formulate a balance between when to put career skills into practice in the classroom, and when to perhaps scale back and work on the theories of teaching technology literacy for the future success of all students in the Engineering/Technology Education classroom.

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