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Bits and Pieces

Welcome to JSTE

As I was thinking about this being the first volume of the new JSTE, I started to reflect on how important it is to be the first in this country, or number one. When I looked back in history I came up with many significant firsts that seem to be very important to us. Some of the important firsts that came to me were from the space program: the first man in space, the first woman in space, and of course the first-man on the moon. Getting away from the space program we can go into sports where in any race the first across the finish line is important, finishing first in the college football polls, and of course first place in world cup soccer. Bringing in technology brings to mind the first automobile, the first airplane flight, and the first Atomic bomb that has changed the world. Today we continue to have many firsts, one of which has brought a major change in American Politics was the election of our first Afro-American President.

Now we have another important first to add to our growing list of firsts. This is the first volume of the Journal of sTEm Teacher Education. (JSTE) which covers the areas of Science, Technology, Engineering, and Math Teacher Education (STEM). Volume 47-2 is the first JSTE journal and has been in the works for a long time. JSTE was organized to bring our readers a wider range of topics to meet the needs of a changing world. It is with this in mind that I would like to **welcome everyone to the first JSTE volume 47-2.**

In this Issue

In this first issue of JSTE you will find three very interesting manuscripts that highlight what the new journal is all about. Volume 47-2 starts off with a manuscript *Two Approaches to Engineering Design: Observations in sTEm Education* by Todd Kelley, Daniel C. Brenner, and Jon T. Pieper. The authors conducted a study that compared two different approaches to engineering design curriculum, *Project Lead the Way* and *Engineering Projects in Community Service.* The researchers conducted a qualitative study that compared indicators such as engineering reasoning, data on the nature of students, and how students define problems.

In the second manuscript Jeremy Jordan and Christopher Curtis conducted an interesting study titled *Evaluating the Impacts of Technology Education on Military Maintenance Students.* In this study the authors present the finding of a study done to identify the three specific areas used to train airmen in the vehicle maintenance field.

The third manuscript in this volume, *An Assessment of the "Diploma in Computer Engineering" Course in Technical Education* was authored by Jinsoo Kim and Kul B. Basnet. Research conducted by the authors analyzed current issues and future policy strategies associated with employment opportunities. Findings showed that the government can play a vital role to improve the employability of graduates by taking necessary steps in monitoring and supervision of institutions.

The work done by the authors in these three manuscripts helps get the new JSTE off to a great start, I am sure you will enjoy reading them and future manuscripts in upcoming volumes of JSTE.

Two Approaches to Engineering Design: Observations in sTEm Education

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Abstract

A comparative study was conducted to compare two approaches to engineering design curriculum across different schools (inter-school) and across two curricula *Project Lead the Way* and *Engineering Projects in Community Service* (inter-curricula). The researchers collected curricula material including handouts, lesson plans, guides, presentation files, design descriptions, problem statements, and support guides. The researchers conducted observations in the classrooms to collect qualitative indicators of engineering/technology reasoning, collect data on the nature of students' questions, how students define problems, and operate within the constraints of a design problem.

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Observational protocol studies were conducted on students participating in *Project Lead the Way* curriculum programs and with students participating in *Engineering Projects in Community Service* (EPICS). Students were asked to work through an ill-defined problem, in this case the problem of creating a new playground for an elementary school. The data from these protocols were analyzed using a coding process; a list of universal technical mental processes (Halfin,1973) and a computer program OPTEMP, (Hill,1997) to accurately record frequency and time of each mental process employed by the students. The data from the protocol results were used to identify common cognitive strategies employed by the students to determine where these students placed greatest emphasis throughout the observational protocol.

General findings indicated that participants in the *EPICS-High* program were more solution-driven problem solvers, where the *Project Lead the Way* participants were generally problem-driven as defined by Kruger & Cross (2006). Additionally, the participants in both groups had completed advanced courses in mathematics, very little mathematics was employed (less than 3%) to describe constraints of the problem or predict results of proposed solutions. Over half of the students became fixated at some point on the provided picture. (Smith; Ward; & Schumacher, 1993). This study provides important insight about how students solve ill-defined problems, providing vital information for technology education as it seeks to implement engineering design.

Introduction

The purpose of this study was to better understand the current status of engineering-focused curriculum programs at the high school level and its greater impact on student learning.

Specifically, this study examined the implementation of Project Lead The Way (PLTW) and EPICS High, engineering-focused curriculum and its impact on students' abilities to employ the engineering design processes using mathematical and scientific reasoning to solve engineering design problems; a construct of interest to K-12 engineering education and the greater STEM community.

The rise in engagement of secondary engineering education (Douglas, Iversen, & Kalyandurg, 2004) and the increase in development of engineering-focused curriculum for grades 9-12 (Dearing & Daugherty, 2004) provide strong rationale for examining pre-existing secondary engineering-focused programs to evaluate the impact on student learning.

Researchers in technology education have investigated the effects of technology education instruction on performance in mathematics and science for over a decade (Childress, 1996; Merrill, 2001). Findings indicated that engineering drawing and design courses have had a significant impact on student achievement on mathematics standardized end-of-year tests (Dyer, Reed, & Berry, 2006). Another study discovered that engineering design instruction at the middle school level reduced the performance gaps among certain ethnic groups and increased student's conceptual knowledge of science, while simultaneously generating higher order thinking skills such as analysis and synthesis (Cantrell, Pekcan, Itani, &Velasquez-Bryant, 2006). These studies indicate that there is a growing interest in investigating how engineering-focused instruction impacts student's STEM learning.

In addition, several initiatives have started in the last decade to introduce engineering principles and engineering reasoning into grade 9-12 classrooms (Brophy, Klein, Portsmore, & Rogers, 2008). While PLTW and other curriculum programs like EPICS-High focus on different aspects, from engineering problem solving to service learning;

each of these new curriculums share the lack of a cohesive body of systematic and rigorous research studies investigating the effectiveness of their programmatic efforts. Specifically, there is a lack of investigation on higher order thinking, open-ended problem solving and the development of design and engineering knowledge/skills (Chaker, 2008).

Dyer, Reed, and Berry (2006) recommended more research on the instruction of engineering design to accurately determine what elements of instruction are most beneficial to student's learning of math and science. Similarly, Sheppard, Pellegrino, & Olds (2008) and Brophy et al. (2008) call for more research on engineering efforts in high schools. This becomes especially pressing, since individual states develop specific engineering standards (i.e. Massachusetts) and specific teacher licensures will likely follow. As these programs continue to grow, there is a need to build a strong base of rigorous research to provide educated and specific feedback on how to improve existing curricula and build a cohesive research agenda on engineering reasoning development in the K-12 grade spectrum.

Participants

Project Lead The Way (PLTW) is a national pre-engineering program that has been implemented into a number of high school and middle schools. The Project Lead The Way program launched in 1997 based on previous work in the 1980s by Richard Blais at Shenendehowa Central School (Blais & Adelson, 1998). Since 1997, Project Lead The Way has grown with over 1300 schools and 175,000 students (Bottoms & Anthony, 2005). Currently, there are over 280 high schools in the state of Indiana alone implementing curricula modules of Project Lead The Way. Two PLTW schools were selected in northwestern Indiana, these schools were selected because they had successfully implemented PLTW at the high school level and had similar student demographics.

Engineering Projects in Community Service (EPICS) is a national engineering-centered, academic service-learning program initiated at Purdue University (Coyle, Jamieson, & Oakes, 2005). The main tenets of service learning are 1) curricular connections; 2) reflection; 3) community partnerships; 4) authentic, complex and ill-structured problems; 5) addressing real needs; and 6) performance-based assessment (Honnet & Poulsen, 1989). Multidisciplinary team partnerships are formed with local not-for-profit organizations to define, design, build, test, deploy, and support engineering-centered projects that significantly improve the organization's ability to serve the community. EPICS-High (for grades 9-12) began in 2007 bringing the engineering design concept into the high school environment. The program has quickly grown to 32 active high schools across the nation with over 650 students served, 50% female students, 48% minority students, and over 50% in free and reduced lunch programs. Two EPIC High programs were selected in northwestern Indiana and were chosen by their record of success in implementing the EPICS High program. Every effort was made to select these participating schools that align with the student body demographics.

Table 1. Participating School General Student Demographics

	PLTW 1	PLTW 2	EPICS 1	EPICS 2
Enrollment	883	1606	1833	883
Graduation Rate	75.7%	92.2%	83.8%	75.7%
White	72%	88%	86%	72%
Hispanic	25%	5%	7%	25%
Multicultural	2%	3%	2%	2%
Asian	1%	2%	1%	1%
Black	1%	2%	3%	1%
Native American	1%	0%	1%	1%
Surrounding Area	Rural	Urban Fringe	Urban Fringe	Rural

Research Questions

This research was guided by the following research questions. Since the nature of our research is comparative, the result to each of the questions will be compared across different schools (inter-school) and across curricula (inter-curricula):

1. What are the most common elements within student dialogues as they define engineering, engage in student collaboration and class discussions when seeking to solve engineering design problems? Which attributes or elements of engineering are missing or strongly represented?
2. What are common cognitive and meta-cognitive strategies employed by high school students as they work to solve an engineering design focused problem?

3. What elements in the engineering design problems (or in the curriculum unit) encourage teachers to engage mathematical and science curricula elements and support mathematical reasoning or scientific reasoning of their students?

Methodology

The research team collected curricula material from all participating classrooms to analyze. This included: textbooks, handouts, lesson plans, PowerPoint files, design descriptions, problem statements, and support guides. The researchers conducted observations in the classrooms to collect qualitative indicators of engineering/technology reasoning, collect data on the nature of students' questions, how students define problems, and how they operate within the constraints of an engineering design problem.

Next, a protocol analysis session was conducted with a group of three student volunteers from each site. Each volunteer was given the same design problem (the transfer problem), see Appendix A. Each student was asked how they would proceed from the given problem statement in order to improve the current condition described in the statement. The students were asked to define the problem, list all constraints that they impose on this problem, and describe how he or she would proceed to solve the problem. The participants were asked to verbalize their thoughts as they worked through the ill-defined problem (verbal protocol methodology). The researchers prompted participants to keep talking through the problem. The testing sessions were limited to thirty minutes, most lasted around ten to fifteen minutes. Certainly, in the time constraint of a testing session, a student would be unlikely to reach the final stages of the design process. However, one of the most important stages of the engineering design process occurs at the onset of a technical problem: 'framing the problem' is this important stage. Experts in the field of design identify that framing the problem is a critical step to the design process which occurs as soon as the designer is presented with a technical problem (Dym, Agogino, Eris, Frey, & Leifer, 2005; SchÖn, 1983). The transfer problem was developed to share characteristics of an ill-defined, complex, and dynamic design problem (Jonassen, 2000).

Analysis

The project involves two separate analyses of artifacts, (1) curricula materials, and (2) results from selected students transfer problem analysis. Both forms of data were analyzed with an analytical induction framework (Bogdan & Biklen, 1992) that similarly to the constant comparative method of grounded theory (Strauss & Corbin, 1990), combines data analysis, further literature review, and theory-building in a cyclical manner. In the analytical induction approach, data built the basis for further descriptions and interpretations, and in contrast to grounded theory is informed by prior research.

As students progressed through the transfer problem session, the students' cognitive processes were identified and coded from a list of 17 universal mental processes (Halfin (1973). A computer analysis tool called the Observation Procedure for Technology Education Mental Processes (OPTEMP) (Hill, 1997) was utilized to capture, record, and organize the codes from each transfer problem session. The researchers coded the actions and cognitive processes used by each student participant as he or she worked through the engineering design problem.

Findings

Classroom Observations:

A total of three class observations were conducted at each PLTW and EPICS-High site. Each PLTW and EPICS High class session was 90 minutes for a total of 270 minutes of observation at each site.

Project Lead the Way Observations

The course observed was PLTW *Principles of Engineering*. The PLTW students were working on marble sorting activity during the observation sessions, the activity required student teams to design and build a device to sort marbles by color using Fishertechnik parts. The nature of much of the classroom dialogs were regarding Fishertechnik parts (motors, sensors, structures, etc) and how the students were planning to connect the various parts to make the device function properly. However, as the student teams' device began to be tested, malfunctions often occurred. As a result of these device malfunctions; students worked as cohesive teams to troubleshoot various problems encountered. Student dialogs were healthy problem solving conversations and represented cooperative team efforts. However, students did not appear to be using a systematic approach to solve problems. The students approach to solving problems was reactive as they employed trial and error approaches, which might also be described as “tinkering”. Students often were observed reconfiguring the device parts such as wires, motors, and sensors.

EPICS High Observations

Both EPICS High participating schools were observed for a total of three class observations. One important observation about both EPICS High classes was the use of an engineer's notebook. Both EPICS High programs required students to obtain and keep an engineer's notebook for the course. The EPICS High School #1 class was discussing "great teams" during one of the classroom observations and "community" during another class observation. The community discussion was an EPICS High created lesson titled Your community…My community. The instructor led a class discussion by asking questions like "How big is your community? Where does it begin and end?" The instructor encouraged students to think about how they individually define community, what did community mean to them. Later in the class, the discussion led to the brainstorming of community service projects to be explored by the class. One researcher had a conversation with the EPICS #1 instructor who shared that his school started the EPICS High program to purposefully target the middle level academically performing students instead of targeting the high performing students. The course gave students an alternative to PLTW which the school also offers. The Purdue EPICS program provided a $48,000 grant to provide the EPICS school #1 with new laptops for all the students to use in the class. The grant also allowed the school to travel to Aurora, IL to the Walter Payton Brew House roundhouse. Last year's EPICS High project was a feasibility study to restore the train roundhouse that is located in the community. EPICS High school #1 class is 12 weeks long.

One classroom observation at EPICS High #2 school found small groups of students (two groups of two students) discussing with the instructor their EPICS High community projects. The instructor reminded the students that they needed to be recording their design thinking in the design notebooks and how the information was to be recorded. The instructor asked the students to present their design project ideas informally to the group. One group selected a community project to design and build a walking path for students on school grounds, the path would need to be wheelchair accessible. The design team was talking about making a pathway using some sort of gravel. The design discussion lead to brainstorming the different material they could use so the wheel chairs won't get caught. The other design team selected a project to create a storage container that would allow teachers to use a magnetic key fob to lock and unlock their laptop computers in a storage unit. Many teachers at this school have complained about having to carry their laptops everywhere they go for security reasons instead of being able to just leave it in their classrooms or one central location. The EPICS High #2 class was small and as a result was a very informal classroom structure, however there was good classroom dialogue regarding the design process. The instructor emphasized the importance of creating a clear and concise problem statement and recording design work in the engineer's notebook. The EPICS High #2 instructor was new to the EPICS High program and had just completed EPICS training in the summer of 2009. The EPICS High #2 school program runs the EPICS High course as a club and not an official class; students do not get course credit and meet after school hours.

Curriculum Documents

A review of PLTW curriculum documents for the course *Principles of Engineering* revealed a focus on teaching students about systems, subsystems, open and closed loop systems, basic computer programming, and troubleshooting problems within a system. Later in the semester, students also learned about basic statics and dynamics. Furthermore, students were taught how to use free body diagrams and conduct basic vector analysis. This knowledge would have been helpful for students who participated in the transfer problem. However, this instruction came after the transfer problem testing session. Upon review of the *Principles of*

Engineering curriculum, the researchers identify that the students are exposed to a limited scope of the engineering design process. PLTW curriculum program consists of a series of courses in pre-engineering; therefore it is unfair to fully assess students design capabilities upon their completion of just one course. Assessment of students who have experienced all the PLTW courses would be ideal such as in the PLTW capstone course: *Engineering Design and Development*. This course was studied in a similar protocol analysis study (Kelley, 2008). However, the schools in this study did not offer this course. Furthermore, most of the students used in this study had taken *Introduction to Engineering Design* that provided a broader overview of the engineering design process so students should have been prepared to employ the engineering design process to solve the transfer problem.

The EPIC High curriculum documents that were studied were lesson plan documents taken from EPICS High Curriculum Module 1- Design, week 3. The activities in this module focus on design notebooks. One activity required students to assess their current note-taking skills by examining their notebooks they keep for other classes. The activity asks students to brainstorm in a small group how the design notebook differs from traditional class notebooks.

Other similar class activities included making use of other people's design notes, building note taking skills, and building organizing skills for design notebooks. Lessons for later in the course focused on the topic of solving engineering problems in teams. These lessons required students get into small or large design teams and work to solve some ill-defined problems. One problem was as follows:

"In your group, solve the following design problem:

- Landfill space is rapidly running out. Develop a plan to eliminate your city's dependence on the local landfill.

Imagine, for now, that the city's population is 100,000.

- As you solve this problem, each member should take notes according to your design notebook guidelines."

(EPICS High curriculum Module 1- Design lesson plans, p.29).

When students were finished exploring possible solutions, they were required to compile a design record providing a design rationale including experimental measurements, sketches, safety precautions, design criterion rationale. Students were also asked to consider assessing how they functioned as a design team during the assignment. This exercise in open-ending problem solving would provide ideal experiences for students and should prepare students for the transfer problem, see Appendix A.

Ill-defined Transfer Problem Session:

Table 2. Transfer Problem Participants' Coursework

Participant	Grade level	Math Courses	Science Courses	Technology Courses
PLTW 1	10	A1, G	ICP	AutoCAD, POE
PLTW 2	10	A1, A2	Biology, Physics	IED, POE
PLTW 3	10	A1, A2, G	Bio, Chem	IED, POE
PLTW 4	10	G, A-AP		IED, POE
PLTW 5	12	G, A2, T, PC, C		IED, POE, Bio-Tech
PLTW 6	11	G 1, G2, A3-A4, T, PC	Bio, Chem, Phys	IED, Design
EPICS 1	10	A1, G	Bio, ICP	EPICS, IED
EPICS 2	12	A1	Bio, Zoology, ICP	EPICS, Manufacturing, Communications, Construction, Robotics, Machining
EPICS 3	12	A2, G, PC, S	Bio, Chem	IED, EPICS
EPICS 4	12	A1, A2, G, PC, C	Bio, Chem, Phy, AP Phy	IED, POE, EPICS
EPICS 5	12	A1, A2, G, PC, C	Bio, Chem, Phy, Chem2	Manufacturing, Transportation
EPICS 6	12	A1, A2, G, PC,C	Bio, Chem, Phy, Chem2	EPICS

Math Courses Key: A1-Algebra; A2- Algebra II; G- Geometry; S- Statistics; T- Trigonometry; PC- Pre-Calculus; C- calculus.
Science Course Key: Ana- anatomy; Bio- Biology; Chem- Chemistry; ICP- Integrated chemistry and Physics; Phy- Physics.
PLTW Course Key- IED- Introduction to Engineering Design; POE- Principles of Engineering

Project Lead The Way Transfer Problem Results

There were several similarities in the Project Lead The Way participant groups when comparing their employed cognitive processes during the protocol session. Out of the seventeen cognitive processes that were first identified by Halfin (1973), the participants only used eight of the processes, see Table 3. Due to testing session constraints such as time limits, location, and available resources, it was expected that cognitive processes such as *models/prototypes, measures,* and *testing* as well as other cognitive processes would not be used when developing a design solution. On average the PLTW students used the *analysis* (AN) cognitive process 37.6 % of the time with a range of low 18% to a high of 61%. The *design* (DE) cognitive process was used 36.5% of the time with a low 21% and a high of 53% of the time. These were the two most employed cognitive processes by the PLTW participants. Besides the quantitative data that was collected, there were several similarities in the ways that the students went about solving the problem.

Of the six PLTW students that were given this ill-defined problem, there was distinctive common pattern when comparing the two female participant results, see Figure 1.1 & 1.2 and Table 4 & 5, participants #2 & #5 were females. Although the research design did not call for comparison of participants' design thinking by gender, the frequency of the cognitive processes of the female students were similar, where as the male students varied. Although these results are interesting, the researchers acknowledge that a greater sample size (n) would be necessary to generalize the finding.

Table 3. Halfin Code (1973)

AN	Analyzing
CO	Computing
DE	Designing
DF	Defining Problems
ID	Interpreting Data
MA	Managing
MO	Modeling
PR	Predicting Results
QH	Questioning / hypothesis

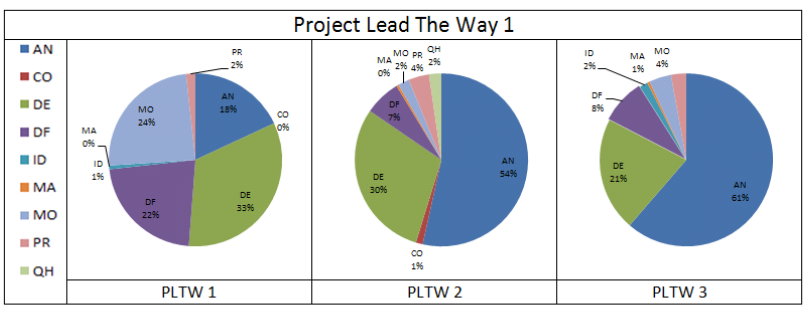

Fig. 1.1: Project Lead Way Participating School #1 Time Breakdown

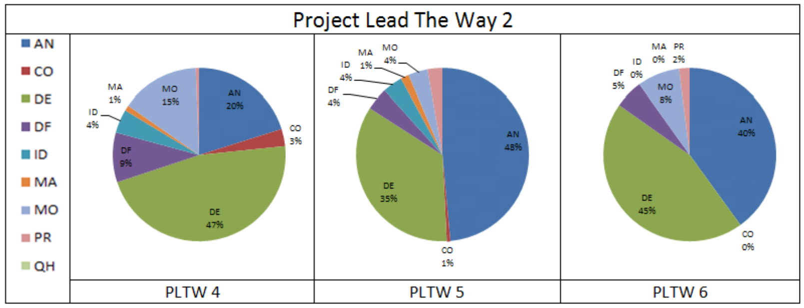

Fig. 1.2: Project Lead Way Participating School #2 Time Breakdown

EPICS High Transfer Problem Results

With the exception of EPICS High participant #3, all other EPICS High students spent 1/3 or more of their time designing solutions with a high of 46 % time on (DE) Designing for EPICS participant # 6 to a low of 20% EPICS participant #3. On average, each EPICS High participant used seven of the nine Halfin coded cognitive strategies that were employed. In general the EPICS High students not only employed multiple cognitive strategies but also spent an ample percentage of time employing a variety of strategies. EPICS #1 and EPICS # 6 are the two female participants. See figures 1.3 & 1.4 and Tables 6 & 7.

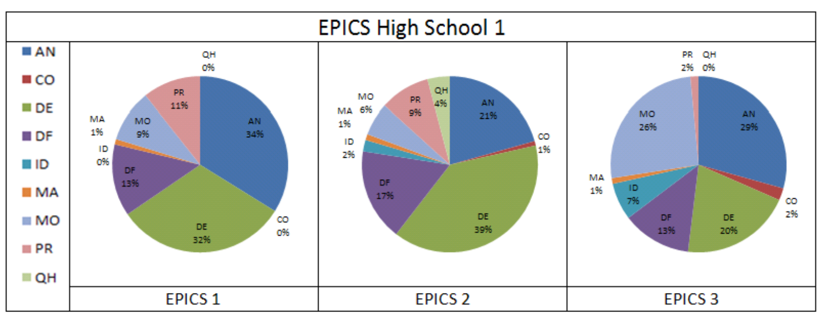

Fig. 1.3: EPICS High Participating School #1 Time Breakdown

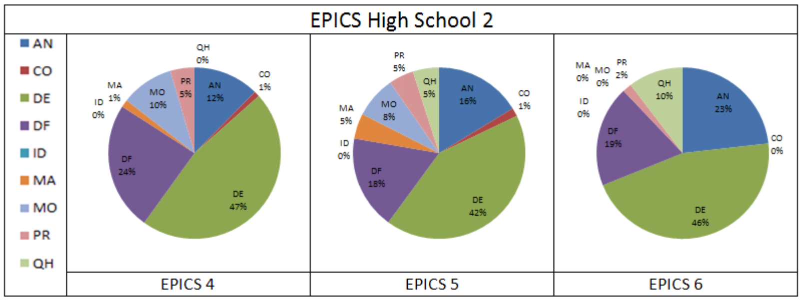

Fig. 1.4: EPICS High Participating School #2 Time Breakdown

PLTW results compared with EPICS High results

The results of the EPICS High transfer problem observational protocol sessions reveal that in general the EPIC High students used a greater variety of cognitive capabilities when designing a solution to the transfer problem compared with PLTW transfer problem results. Clearly, DE (Designing) and AN (Analysis) were the most often employed cognitive strategies for both groups, EPICS High participants employed a variety of other cognitive strategies for an ample amount of time, possibly indicating that the EPICS High students engaged in a more well-rounded approach to design by employing multiple cognitive strategies. Both groups with the exception of one participant in each program (PLTW #3 and EPICS #3) employed 1/3 or more percentage of their time on the transfer problem in DE (Designing). This is a very promising result because it indicates that the students were successfully able to move from the problem space to the solution space. However, 4 out of the 6 PLTW participants focused 40% or more of their time on (AN) Analyzing. One EPICS High student spent 34% of time on (AN) Analyzing, all other EPICS High participants dedicated less than 30% of their time using Analyzing as a cognitive strategy. It is important to note that (AN) Analysis

Halfin code was recorded by the researchers when participants were observed breaking down the problem and identifying constraints and criteria. (AN) Analysis along with (DF) Defining Problems are cognitive strategies that represent the 'problem space' of design thinking. Lawson (1979), identified problem solving strategies as either 'problem focused' or 'solution focused', and claimed the 'solution focused' strategies were more representative of a design-based problem solving strategy.

Only PLTW participants #2 and #3 appear to be stuck in the problem space, a common pattern for novice designers that limits their ability to generate solutions (Cross & Dorst, 1999; Dorst & Cross, 2001). The PLTW participants that place emphasis on (AN) Analysis may be performing this way because the PLTW students have had experience in identifying constraints and criteria in their PLTW course work and classroom activities. For example, the PLTW *Principles of Engineering* project, the marble sorter activity (see description above in classroom observation section of the findings) require the student teams to troubleshoot problems that occur in their design solutions by identifying what constraints and criteria are limiting the success of the device. This result of this study reveals that these PLTW students are possibly transferring their knowledge and experience from the *Principles of Engineering* class to the transfer problem sessions. Although these results are promising to illustrate a curriculum program having impact on students ability to transfer their learning to an open-ended transfer problem, too much emphasis of (AN) Analysis can limit students' abilities to move from problem space into solution space (Cross & Dorst, 1999; Dorst & Cross, 2001).

Limited Mathematical Thinking

Both EPICS High and PLTW student participating in the transfer problem observational protocol sessions had limited employment of (CO) Computing. The Halfin code computing is defined as “The process of selecting and applying mathematical symbols, operations, and processes to describe, estimate, calculate, quantity, relate, and/or evaluate in the real or abstract numerical sense”. The researchers did not expect that participants were going to be generating multiple mathematical models to develop solutions to this transfer problem in a 15 -30 minute test session; however, the transfer problem was created purposely with numbers embedded within the problem to see if students would attempt to quantify, estimate, calculate, or describe design solutions using the numerical information provided within the open-ended problem. None of the six participants spent more than 3% of their design thinking time using the (CO) Computing strategy. PLTW #4 spent the greatest amount of time computing, dedicating 3% of time on this strategy, five other participants (PLTW #1, 3, 6 and EPICS #1, 6) never employed computing once during the testing session. Like the results of a similar study, Kelley (2008), found that often the participants with the least amount of math instruction employed the most mathematical thinking. PLTW # 4 had only two math courses (Geometry and AP Algebra) but applied the most mathematical thinking for 3% of time compared with PLTW 5, PLTW 6, EPICS 4, EPIC 5, and EPIC 6 that had five or more math courses but employed (CO) Computing for 1 or less % of time. In fact, PLTW 6 had taken six math courses and EPICS 6 had taken five courses and neither participant employed any mathematical thinking during the protocol session. Some leaders in engineering design based instruction at the secondary education level suggest that mathematical modeling and mathematical analysis are key missing pieces in the technological design process (Hailey, et al., 2005; Wicklein, 2006). Although all student participants have taken advanced coursework in mathematics ranging from Algebra 1 to AP

Calculas, the participants' employment of mathematical strategies was minimal. This is an extremely important finding that could limit supporters of PLTW and EPICS High to promote these curriculum projects as effective strategies for improving STEM education.

Design Example Fixation

As stated above, the students were given an ill-defined problem presented on a one page handout. On the problem statement handout, there was a stock photo of a school under construction and its surrounding areas; see appendix A. The photo was used to provide a general context to the problem statement. All of the participants at some time in the testing session referenced the photo and sometimes analyzed the photo even though the photo was never referenced in the problem statement. Each participant at some point in the testing session used the photo like a template for the location of their playground. This discovery was unexpected; however the phenomenon has been discovered in other design studies (Smith, Ward, & Schumacher, 1993). Smith, et al. (1993) have discovered that providing a designer, both novice and expert with a design sample can cause the designer to become fixated on the design example, thus, limit and influence the designer. Kelley (2008) also found that participants in a similar protocol study were often fixated on the picture that was included in problem statement. Some participants in that study even asked questions about the picture and carefully studied the picture's URL citation.

In this study, students were potentially limited in their creative thinking to the context of the photo of a school under construction. This can be an extremely important discovery for K-12 engineering educators because it illustrates the potential negative impact of providing an existing design example to students before they generate their own design ideas or even to provide images or illustrations representing the problem. Furthermore, this result of the study may indicate that students often believe that solutions to assigned problems are contained within the student handout.

Table 4. Project Lead The Way School #1 Transfer Problem Results

	PLTW #1		PLTW #2	
Halfin Code	Freq.	Time	Freq.	Time
AN	10	01:38.4	13	05:48.5
CO	0	00:00.0	1	00:08.4
DE	8	03:00.7	8	03:14.2
DF	6	02:00.0	1	00:44.1
ID	1	00:03.8	0	00:00.0
MA	0	00:00.0	1	00:02.8
MO	8	02:12.4	1	00:13.6
PR	2	00:09.5	3	00:25.1
QH	0	00:00.0	2	00:15.0

	PLTW #3		PLTW School 1 Mean Scores	
Halfin Code	Freq.	Time	Freq.	Time
AN	11	07:40.3	11.3	05:02.4
CO	0	00:00.0	0.3	00:02.8
DE	8	02:39.7	8.0	02:58.2
DF	1	01:02.8	2.7	01:15.6
ID	2	00:11.6	1.0	00:05.1
MA	2	00:03.4	1.0	00:02.1
MO	1	00:31.1	3.3	00:59.0
PR	4	00:21.4	3.0	00:18.7
QH	1	00:01.5	1.0	00:05.5

Table 5. Project Lead The Way School #2 Transfer Problem Results

	PLTW #4		PLTW #5	
Halfin Code	Freq.	Time	Freq.	Time
AN	15	02:56.2	34	11:17.1
CO	3	00:27.9	2	00:09.6
DE	17	06:47.2	32	08:06.5
DF	2	01:21.1	3	00:59.2
ID	5	00:38.6	8	00:51.8
MA	2	00:09.0	3	00:21.8
MO	8	02:08.7	6	00:50.6
PR	2	00:05.6	8	00:38.9
QH	0	00:00.0	0	00:00.0

	PLTW #6		PLTW School 2 Mean Scores	
Halfin Code	Freq.	Time	Freq.	Time
AN	11	04:19.3	20.0	06:10.9
CO	0	00:00.0	1.7	00:12.5
DE	21	09:07.5	23.3	08:00.4
DF	2	00:58.6	2.3	01:06.3
ID	0	00:00.0	4.3	00:30.1
MA	1	00:12.7	2.0	00:14.5
MO	14	02:00.3	9.3	01:39.9
PR	1	00:03.9	3.7	00:16.1
QH	2	00:32.6	0.7	00:10.9

Table 6. EPICS High School #1 Transfer Problem Results

	EPICS #1		EPICS #2	
Halfin Code	Freq.	Time	Freq.	Time
AN	4	02:36.4	9	01:52.1
CO	0	00:00.0	1	00:04.5
DE	5	02:26.6	14	03:31.8
DF	1	01:01.2	4	01:39.1
ID	0	00:00.0	2	00:11.4
MA	1	00:04.5	2	00:05.9
MO	3	00:44.4	3	00:32.8
PR	0	00:00.0	4	00:49.9
QH	4	00:49.4	1	00:22.3

	EPICS #3		EPICS School 1 Mean Scores	
Halfin Code	Freq.	Time	Freq.	Time
AN	14	04:08.8	9.0	02:52.4
CO	1	00:18.9	0.7	00:07.8
DE	14	02:53.0	11.0	02:57.1
DF	7	01:48.5	4.0	01:29.6
ID	6	00:57.9	2.7	00:23.1
MA	1	00:08.9	1.3	00:06.4
MO	12	03:40.0	6.0	01:39.1
PR	1	00:12.7	1.7	00:20.9
QH	0	00:00.0	1.7	00:23.9

Table 7. EPICS High School #2 Transfer Problem Results

	EPICS #4		EPICS #5	
Halfin Code	Freq.	Time	Freq.	Time
AN	6	00:40.9	5	00:45.4
CO	1	00:03.5	1	00:04.4
DE	10	02:34.4	7	01:57.8
DF	3	01:20.3	1	00:49.4
ID	0	00:00.0	0	00.00.0
MA	1	00:04.7	1	00:13.3
MO	4	00:32.8	3	00:27.0
PR	3	00:15.1	3	00:13.0
QH	0	00:00.0	2	00:13.8

	EPICS #6		EPICS School 2 Mean Scores	
Halfin Code	Freq.	Time	Freq.	Time
AN	5	01:21.6	5.3	00:56.0
CO	0	00:00.0	0.7	00:02.6
DE	8	02:40.8	8.3	02:24.3
DF	2	01:07.1	2.0	01:05.6
ID	0	00:00.0	0.0	00:00.0
MA	0	00:00.0	0.7	00:06.0
MO	6	01:13.7	2.7	00:44.5
PR	4	00:06.0	3.3	00:11.4
QH	1	00:36.4	1.0	00:16.7

Inter-rater Reliability Results

Two researchers were used to code the transfer problem observational protocol sessions. The two researchers were trained by the PI of this study on how to interpret the Halfin code and how to record the codes using the OPTEMP software. The researchers practiced coding protocol sessions using sample videotape sessions as a part of their data analysis training. Both research assistants were present for all transfer problem sessions and each researcher coded independently using the OPTEM software. The researchers hope for correlation close to 1, indicating that both raters agree and affirm the reliability of these results. The lowest Pearson correlations were .76 and .75 for PLTW #1 and PLTW #2, these were the first two transfer problem sessions that were coded by the research assistants, see Table 8. It is logical that the researchers were refining their coding abilities during these first two sessions. However all other correlations were .93 or higher indicating a strong correlation and reliable coding of the transfer problem sessions.

Limitations

The researchers acknowledge the study has a small *n* of approximately 60 students observed in PLTW and EPICS High classes and an *n* of 12 participants for the observational protocol; therefore, the result of the study are not generalizable to all secondary engineering design programs.

Other possible limitations include a potential bias regarding PLTW and EPICS High. According to Merriam (2001) researchers must acknowledge potential biases within the final report of the study. The researchers acknowledge that a potential bias could exist regarding both PLTW and EPICS High due to the fact that the researchers work within an engineering/ technology teacher program that provides undergraduate students with certification in PLTW courses and the fact that EPICS High was created by Purdue engineering education faculty. To help ensure that such biases did not taint research findings, the researchers implemented methods such as Merriam's observational elements guide (2001). The observational elements guide provided researchers with guiding questions that required reflection on a variety of factors in order to maintain an objective perspective as the researcher collected observational data. The researchers also use *triangulation* methods to provide multiple perspectives and multiple forms of data. Finally, researchers used multiple raters on the observational protocol transfer problem session to maintain consistent and reliable data collection. These are sound research methodologies that can help to ensure an objective data collection process.

Table 8. Inter-rater Reliability- Pearson R results

PLTW participants	Pearson R	EPICS High Participants	Pearson R
PLTW #1	0.76	EPICS High #1	0.98
PLTW #2	0.75	EPICS High#2	0.99
PLTW #3	0.92	EPICS High #3	0.99
PLTW #4	0.93	EPICS High #4	0.94
PLTW#5	0.99	EPICS High #5	0.94
PLTW#6	0.93	EPICS High #6	0.95

Conclusions / Implications

The researchers acknowledge that classroom observations were limited to approximately 60 students observed in PLTW and EPICS High classes and a sample of 12 participants for the observational protocol; therefore, the result of the study are not generalizable to all secondary engineering design programs. However, all members of the STEM education community should carefully consider the results of the findings from this research. The results of this study indicate that students from both engineering design curriculum programs successfully develop problem solving abilities to move from ‘problem space’ to ‘solution space’ as they worked through an open-ended ill-defined problem. Furthermore, classroom observation revealed that student design teams had healthy design discussions and worked cooperatively to solve technical problems.

However, students were limited in their ability to use mathematical thinking as a design tool to help create design solutions. Although most of the students had advanced math classes with over 50% having 3 or more classes (four participants had a total of five math classes), students spent 3% or less time using mathematics in their design thinking. This finding confirms prior findings in similar research. Kelley (2008), a study of two approaches to design instruction also used a protocol session with a transfer problem found that mathematical thinking was a limited cognitive strategy employed by the protocol session participants. Moreover, Kelley and Wicklein in a national descriptive study of engineering design curriculum content found a low emphasis on mathematics and engineering sciences in current technology education curriculum (2009a). Technology education teachers also place a low emphasis on mathematics in student project assessment; the individual item *using mathematics to optimize and predict design results* yielded the lowest percentage of assessment time (Kelley & Wicklein, 2009b). It appears that technology education teachers are not placing great emphasis on using mathematical models to predict design results. Technology education teachers appear to recognize this limitation and have identified it as a teacher challenge. Kelley and Wicklein (in-press) in the national status study of technology education regarding engineering design also found technology education teachers identified: *integrating the appropriate levels of mathematics and science into instructional content* (mean of 2.49 on a four-point Likert) as a major challenge implementing engineering design content. This was the highest mean score for an individual teacher challenge item, thus indicating this is major concern for technology education teachers. More efforts need to be placed on identifying appropriate mathematical models and science inquiry examples that teachers can use to integrate STEM concepts in engineering design curriculum content. EPICS High teacher #2 provided some insight on why students had limited use of mathematics in the transfer problem in response to the question:

> "Do you believe that your students will employ mathematical thinking (when appropriate) as they work to solve the transfer problem?"

EPICS High teacher #2's response:

> "Yes, I have given similar design problems that required students to use math to solve the problem. However, if students can see that they don't need the math to begin designing then I think they won't use math….if they can find a way to solve the problem without math…they will."

These research findings should be considered by educators and curriculum developers of pre-engineering or secondary engineering design curriculum, of which many also promote these programs as ideal platforms for STEM education. These findings indicate that currently the transfer of STEM learning through the engineering design process on ill-defined problem solving is limited. Engineering design curriculum developers must be more purposeful in creating learning experiences that embed mathematical problems and science inquiry activities into the engineering design process. More efforts need to take place to locate appropriate ill-defined problems that can be explored through the engineering design process that will authentically engage students in the *analysis* and *optimization* stages of the engineering design process.

Furthermore, greater efforts must take place across the nation to provide professional development opportunities to assist math, science, and technology education teachers to locate appropriate levels of STEM subjects for delivery in pre-engineering or secondary engineering design curriculum.

Future Studies

The researchers suggest the following studies for the future that can extend the results of this research:

This research study has provided great insights into several approaches to teaching engineering design content at the secondary level. From this study, other practitioners in the field of technology education will better understand what is taking place in secondary education classrooms regarding the teaching of engineering design. However, more information is needed to help properly inform the field about this construct. Consequently, the following recommendations are suggested for further research to inform the field of technology education:

a) Larger n for observational protocol studies

Great insight has been obtained from conducting a study to extend the results of prior work (Kelley, 2008). The sample size of 12 students for the transfer problem nearly doubled the prior work (Kelley, 2008); however a sample size of 12 is too small to generalize to the population. More observational protocol studies need to be conducted on students engaged in design activities that have authentic levels of math and science inquiry embedded into the design problems. This type of study can help locate an appropriate balance of cognitive capabilities that will have the greatest impact on STEM abilities and produce effective designers and technical problem solvers.

b) Expert designer studies

The field of K-12 engineering education can learn from expert engineers and expert designers through observational protocol studies of these experts working through a transfer problem. A study of this type will help educational leaders in K-12 engineering education determine possible appropriate levels of various cogitative capabilities employed at an expert level. Currently, the researchers can only indicate based upon personal opinion that less than 3% of a student's engineering design thinking dedicated to mathematical thinking (CO) Computing is not at an acceptable level. Expert designer observational studies can provide great insight into what percentage of time on various cognitive capabilities indicate an individual is functioning as an expert designer.

c) Revisit Halfin's study

Harold Halfin (1973) conducted his Delphi study of 10 expert technical problem solvers back in 1973, others have revised the study before Wicklein and Rojewski, 1999 and Hill, 1997 but now is an appropriate time to revisit this research and locate expert technical problem solvers that represent the type of designers that employ the engineering design process but also exemplify the type of professionals who would have credentials to function effectively in today's global society, see Friedmen,2005; Pink, 2005. Results from a study using Halfin's study as a model could help leaders in K-12 engineering education identify appropriate competencies for secondary engineering education.

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Appendix A. Transfer Problem

Problem

A new K-5 elementary school has been constructed in the local area and new playground still needs to be designed. You obtained the following specifications:

The school is expected to have around 500 students. The area of the playground has not been determined and space is limited. Safety of both students and school properties needs to be considered. For example, if students are playing softball too close to a building, they would risk breaking windows. At minimum, one entire grade will use the playground space at once. The playground needs to be attractive and fun for all students.

Your Task

Describe how you would design the playground for the school in the problem statement. Please describe all assumptions, information you need to obtain, and justification of use of space as you “think aloud” your strategies for developing the solution.

Evaluating the Impacts of Technology Education on Military Maintenance Students

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Abstract

The United States Air Force (USAF) provides career and technical education (CTE) to a wide variety of specialty career fields. Training airmen to carry out the mission while honoring the USAF core values of integrity first, service before self, and excellence in all we do is the top priority of military leaders and trainers. Vehicle maintenance is especially important as one minor malfunction could cause multiple injuries and deaths. Vehicle maintainers are thus trained in grueling learning environments and follow arduous regulations to ensure the utmost adherence to standards. This paper presents the findings of a recent study at the Port Hueneme Naval Station in California, home of the technical school of Air Force Vehicle maintenance. The results focus on three specific areas that contribute to performance: student learning preferences, Armed Services Vocational Aptitude Battery (ASVAB) scores and other personal characteristics, and a comparison of alternate training aids.

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Introduction

Training students to reach their potential and go beyond their abilities should be at the forefront of a leader's motivation and goals. This is true in any arena – high schools, technical schools, undergraduate institutions, graduate schools, and the U.S. military. This concept is especially important in today's military training schools. Reduced manning and higher operational tempos seen by the U.S. Military has given enlisted personnel increasingly greater responsibilities earlier in their careers and forced them to take on more important roles in the mission of the United States Air Force (USAF). Vehicle maintainers are responsible for ensuring their assigned piece of equipment is operating flawlessly at all times. The Global Deicer is no exception; operators extended 50 feet in the air to de-ice an airplane expect minimal complications with their machinery. It is thus extremely important to make certain Global Deicer maintenance troops are instructed in the finest environment with the most advanced methods available. In fact, tight budgets and increased demand for skilled personnel has the Air Education and Training Command (AETC) constantly looking for more effective methods and tools to deliver that training. One such innovation that was explored recently was the Wiring, Signal Tracing, and 3D Interactive Training Tool developed by Tools for Decision (TFD). TFD claimed their tool would reduce the time needed to teach complex systems, improve student understanding of complex electrical, hydraulic and pneumatic schematics, and result in overall improvement of student performance. As part of AETC's assessment of the new tool, the Air Force Research Laboratory (AFRL) was invited to perform a study on the tool's effectiveness in improving training. The purpose of the study was to determine the effectiveness of the new tool in instructing new students. The idea being tested is whether or not the new Wiring, Signal Tracing, and 3D Interactive Training Tool will have an effect on student performance with a null hypothesis of no effect. The research questions we examined were:

- Will the new tool increase the understanding of the subject material?
- Will the new tool improve performance of the students?
- Will the new tool reduce the amount of time needed to conduct the course?
- How does instruction methodology/delivery affect student performance based on student learning preferences?
- Can we use test scores from the Armed Services Vocational Aptitude Battery (ASVAB) to forecast student performance?
- How do student characteristics such as intellect, extraversion, need for cognition, and age affect performance?

Each of these questions is answered through a series of analyses. Data is collected from each student and used to answer the proposed questions. The following section gives details and the methods used in the study.

Method

To understand the best manner in which to teach the students, the instructors must first understand their students' differences in learning preferences and demographic compositions. Certain types of students will flourish in different environments. The best way to understand these students is through honest communication in a non-hostile environment such as a non-intrusive survey. The enlisted personnel in this study have recently finished basic training and are very conscious of the power of leadership when they arrive at technical school. Instructor-student interaction may be an ineffective method of extracting information. More than likely, students will feel intimidated in an environment such as this and will not honestly convey their thoughts and feelings. For this reason, an outside researcher engaged the students with a written survey to capture characteristic and preferential data. The survey was administered to 95 (90 males, 5 females) military students stationed at the Naval Surface Warfare Center, Port Hueneme Division in Port Hueneme, CA. The students were attending courses at the Air Force Maintenance Training Facility, Detachment 1, 345th Training Squadron on base. Several short courses make up the training environment; this study is concerned with a detailed maintenance techniques course on the Global Deicer.

The study is broken into three sections examining various aspects of the students. The first section contains a review of the learning preferences of the students. There exists a widely accredited idea that a student's performance is related to the preference in which they approach a learning situation and the manner in which that learning situation is presented. Four distinct learning preferences seem to emerge from studies of individuals. From these, a teacher can tailor teaching styles to accommodate student learning preferences. The idea of differing learning preferences among individuals is pervasive in the educational literature (Fleming, 1995; Felder & Spurlin, 2005; Felder & Silverman, 1988), yet there are still skeptics (Kratzig & Arbuthnott, 2006). The literature reveals opposing views on the idea of learning preferences as well as the effects of matching instruction techniques to learning preferences. Nevertheless, a menagerie of research has been devoted to revealing an adequate measure of learning preferences and numerous scales exist. A popular construct and questionnaire is the V.A.R.K. developed by Neil Fleming (Fleming, 2006). This survey is used to determine how students prefer to take in and give out information, and thus can be used to enhance learning. The survey has been used on numerous occasions in the literature (Baykan & Nacar, 2007; Slater, Lujan, & DiCarlo, 2007; Lujan & DiCarlo, 2006; Wehrwein, Lujan, & DiCarlo, 2007). Students learn in different ways, and there is value in understanding the students' learning preferences.

In the second section, we explore the relation of various factors and their effects on student performance at the school. Several factors are explored including Armed Services Vocational Aptitude Battery (ASVAB) scores, intellect, need for cognition, extraversion, and age. The ASVAB is a test administered to military recruits to determine proper placement in the field (ASVAB, 2009). Scores are analyzed and used to place military troops in specific jobs based on their performance in 9 major areas:

- General Science
- Arithmetic Reasoning
- Word Knowledge
- Paragraph Comprehension
- Mathematics Knowledge
- Electronics Information
- Auto and Shop Information
- Mechanical Comprehension
- Assembling Objects

In the study, five composite category scores from the ASVAB are examined; Administrative, Mechanical, General, Electrical, and the Armed Forces Qualification Test (AFQT). The Administrative score is computed from word knowledge and paragraph comprehension areas of the ASVAB. The Mechanical score is computed from the mechanical comprehension, general science, and auto and shop information areas. The General score is derived from the word knowledge, paragraph comprehension, and arithmetic reasoning areas. The

Electrical score is computed from the arithmetic reasoning, mathematics knowledge, electronics information, and general science areas of the ASVAB. The Air Force Qualifying Test (AFQT) is a percentile score between 1 and 99, indicating the percentage of testers that scored at or below the score obtained. The AFQT is comprised of the arithmetic reasoning, mathematics knowledge, paragraph comprehension, and word knowledge areas of performance.

Intellect and extraversion are two of the Big-Five factors discovered by Lewis Goldberg (Goldberg, 1992). Extraversion includes students who are talkative, assertive, verbal, energetic, active and daring. Conversely, a low extraversion score indicates individual characteristics such as shy, quiet, reserved, inhibited, withdrawn and timid. High intellect scores describe a student who is creative, complex, imaginative, bright, philosophical, innovative and introspective. Need for cognition is the tendency for an individual to engage in and enjoy thinking and has been developed and validated in the literature (Cacioppo & Petty, 1982). Understanding the students at this level may give the instructors additional firepower to be one-step ahead in their training techniques.

Finally, an evaluation of the performance of the Wiring, Signal Tracing, and 3D Interactive Training Tool developed by Tools for Decision (TFD) Group is performed. Student performance data were collected to assist in analyzing the effectiveness of the wire tracing tool. TFD hypothesized this training tool would reduce the time needed to teach complex systems, improve student understanding of complex electrical, hydraulic and pneumatic schematics and circuitry, and result in an overall increase in student performance. The 3D interactive computerized training aid is used to teach future mechanics how to maintain/troubleshoot the Global Aircraft Deicing Vehicle. The training tool is computer based and provides detailed displays of electrical, hydraulic, and pneumatic circuits. Complex schematics are simplified by displaying one function per screen, and providing hyperlinks to other screens showing related tasks. Additionally, color-coded animations are used to trace electric, hydraulic, and air flow through various circuits. The implementing organization expects to lessen the time needed to teach complex systems while improving the overall quality of instruction. They also anticipate a cost reduction by reducing the number of operational assets committed for use as training aids. Other projected benefits include increased student comprehension/retention and faster trouble shooting during performance exercises. The school house also hopes to reduce student wash-back and attrition rates attributed to vehicle complexity. The results of this final section will allow AF organizations to make informed decisions regarding future course automatons.

V.A.R.K. Analysis Results

It is important that an instructor understand the learning preferences of their vehicle maintenance students. By understanding their learning preference tendencies, instructors can further tailor their teaching programs to benefit the students' learning. The V.A.R.K. survey was given to the students as part of the survey mentioned above and is referenced in (Fleming, 2006).

The four categories of learning are defined as visual (V), auditory (A), read/write (R), and kinesthetic (K). A student may have one preferred preference or multiple preferred preferences at varying strengths. When multiple learning preferences are present, a student is considered multi-modal. There are positives to each style, multi-modals can learn in many different settings; however normally need to exercise all of these preferences to truly understand something.

A student with a single preference is limited in the environments where he learns well. However, once his preferred mode of learning is achieved he will understand whatever is being presented completely.

Evidence suggests (Fleming, 2006) that males tend towards kinesthetic learning while females prefer a read/write style of learning, our research affirms this (see Figures 1 and 2) as the majority (95%) of the students are male. Figure 1 shows that the majority of maintenance students are multi-modal. Figure 2 shows the breakdown of the 78% of multi-modal learners in Figure 1. Figure 3 shows the overall first preferences (a combination of Figures 1 and 2) of the students. Kinesthetic is the preferred method while read/write comes in a close second. The majority (69%) prefer kinesthetic and read/writing as a learning preference.

Different vocations tend to have different learning styles as well, and kinesthetic learners will most likely gravitate towards occupations where hand-use is prevalent such as mechanics. Being aware of the majority of students' learning preferences in one's domain helps teachers and leaders develop more efficient training techniques. Knowing the majority of the maintenance students prefer one type of learning over another should lead the squadron's management to put additional resources towards this type of learning. Since the majority of the students are kinesthetic and read/write, the leaders should not spend more time in the classroom speaking to the students, but rather more time outside handling the vehicle and possibly forcing them read and write more about what they're learning. Students would benefit from spending more time exploring the actual Global Deicer vehicle and being allowed to practice on the wiring itself. Another idea is to hand out reading material regarding the wiring schematics, as well as pushing the students to write their own descriptions of the material they are learning.

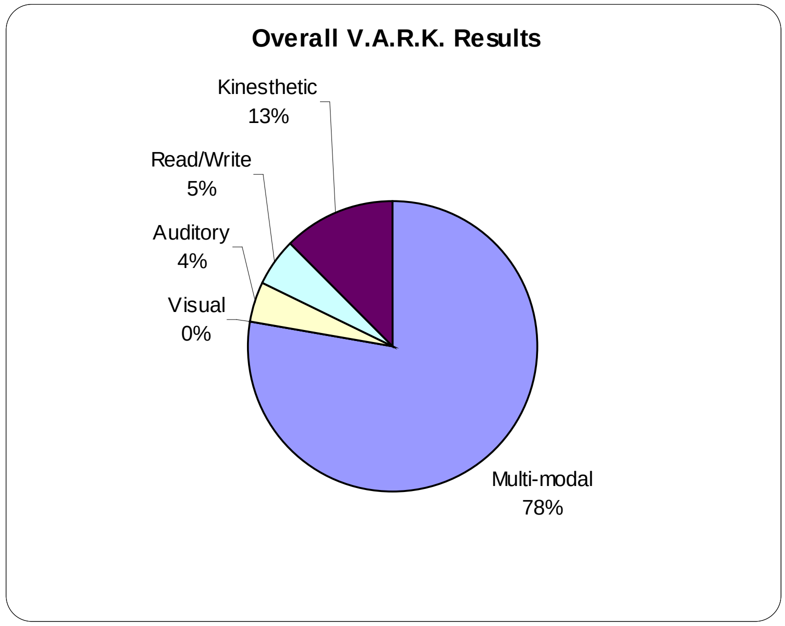
Overall V.A.R.K. Results
Kinesthetic
13%
Read/Write
5%
Auditory
4%
Visual
0%
Multi-modal
78%

Figure 1

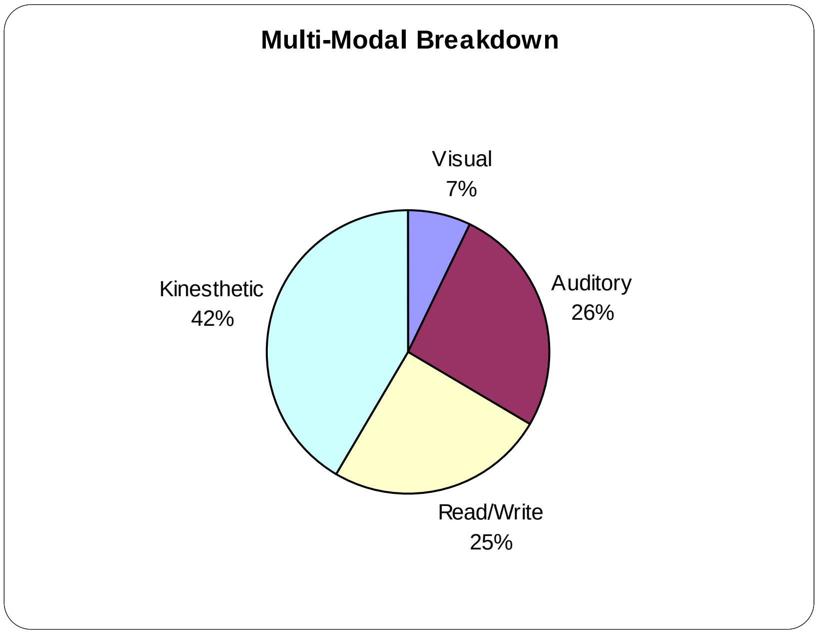
Multi-Modal Breakdown
Visual
7%
Auditory
26%
Read/Write
25%
Kinesthetic
42%

Figure 2

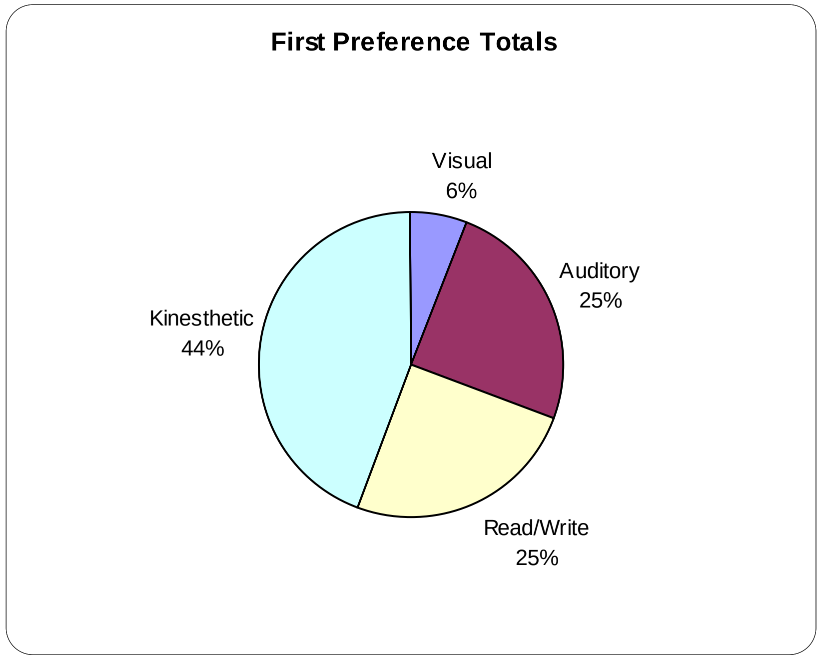

Figure 3

Additional recommendations and further guidance can be obtained at <http://www.vark-learn.com>.

Individual Characteristic Analysis Results

In addition to learning preferences, the survey administered also collected the students Armed Services Vocational Aptitude Battery (ASVAB) scores, intellect, extraversion, and need for cognition. Performance check test scores, final test scores, and an instructor rating were also gathered as dependent variables. This section answers several questions and explores some of the relationships between variables.

The performance check is given after 3 days of classroom exposure to the written material; the students haven't physically worked on the vehicle at the time the test is given. The students are allowed to repair the actual vehicles with their hands the following week before the final test is given. Interestingly, the kinesthetic learners are the lowest performers on the initial performance check and the highest performers on the final test. They start performing well after they have spent hands-on time with the vehicle. The kinesthetic learners are the only group who showed any significant variation between the performance check and the final test, see Table 1. This shows the necessity of allowing the students to spend a lot of time working on the actual vehicle. Finding other ways to reach the students with other learning preferences could also boost final test scores. These findings support the notion that matching instruction to learning preference increases student performance as discussed earlier in the methods section.

Table 1

	Written PC Average	Final Test Average	Statistically Different?
Aural	87.86	86.43	No
Kinesthetic	81.14	90.86	Yes
Read/Write	88.57	86.43	No
Visual	86.00	83.00	No

Does a student's age affect their performance? It may be possible to better organize learning groups based on the students' ages. Rather than putting all the young students in one group and the older students in another group, the instructors could put one of each age group into a learning group together to increase diversity. An ANOVA was performed on three age groups as shown in Tables 2 and 3.

Table 2

Age	Average Test Score	Standard Dev
18-22	85.93	9.2
23-39	94.44	5.1
40+	87.14	12.2

Table 3

	SS	MS	P-value
Between Age Groups	1040.160819	520.0804	0.002018
Within Age Groups	7201.944444	78.282	

Consider a null hypothesis that age does not affect student performance in the course. Table 3 gives sufficient evidence to reject the claim that the three age groups come from populations with the same mean. There exists a significant difference between the three age groups, with the students aged 23-39 being the top performers on the written tests. The young students performed considerably lower than the middle age group. The reasons for this could include the fact that young newly enlisted troops have historically been known to prioritize social interaction during the first years of service as opposed to intense focus on mission. Reasons for lower scores from the oldest group may be the struggle to regain good study habits and loss of knowledge from high school shop courses. If study groups or learning teams are used during the course, it may be beneficial to better disperse the different age groups rather than allow a group of solely 40+ or 18-22 year-olds.

Learning preferences don't appear to have a direct influence on test scores as shown in Tables 4 and 5. Although it appears the kinesthetic learners scored much higher than the visual learners, the number of data points led to an insignificant statistical conclusion. It is noted however that the visual learners were the lowest performers on the tests. This should lead the instructors to seek out additional visual learning aids in order to reach the visual learners more effectively.

Table 4

Learning Preference	Average Test Score	Standard Dev
Aural	86	11.0
Kinesthetic	91	8.7
Read/Write	86	9.0
Visual	83	10.4

Table 5

	SS	MS	P-value
Between Learning Preferences	491.8095238	163.9365079	0.14032
Within Learning Preferences	6182.857143	87.08249497	

		AGE	ADMIN	MECH	GEN	ELECT
AGE	Pearson Correlation	1	-.361**	.145	-.074	-.158
	Sig. (2-tailed)		.000	.162	.475	.126
	N	95	95	95	95	95
ADMIN	Pearson Correlation	-.361**	1	.397**	.663**	.749**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	95	95	95	95	95
MECH	Pearson Correlation	.145	.397**	1	.766**	.651**
	Sig. (2-tailed)	.162	.000		.000	.000
	N	95	95	95	95	95
GEN	Pearson Correlation	-.074	.663**	.756**	1	.678**
	Sig. (2-tailed)	.475	.000	.000		.000
	N	95	95	95	95	95
ELECT	Pearson Correlation	-.158	.749**	.651**	.678**	1
	Sig. (2-tailed)	.126	.000	.000	.000	
	N	95	95	95	95	95
AFQT	Pearson Correlation	-.210*	.923**	.590**	.882**	.784**
	Sig. (2-tailed)	.048	.000	.000	.000	.000
	N	89	89	89	89	89
Needforcognition	Pearson Correlation	.017	.138	.021	.115	.120
	Sig. (2-tailed)	.869	.182	.840	.267	.247
	N	95	95	95	95	95
Extraversion	Pearson Correlation	-.264**	.063	-.123	.049	.002
	Sig. (2-tailed)	.010	.544	.236	.635	.984
	N	95	95	95	95	95
Intellect	Pearson Correlation	-.140	.378**	.201	.402**	.327**
	Sig. (2-tailed)	.175	.000	.051	.000	.001
	N	95	95	95	95	95
LearningPreference	Pearson Correlation	.040	-.067	-.159	-.062	-.131
	Sig. (2-tailed)	.731	.568	.172	.599	.262
	N	75	75	75	75	75
Block2test	Pearson Correlation	.156	.051	.225*	.157	.080
	Sig. (2-tailed)	.130	.625	.028	.129	.443
	N	95	95	95	95	95
WrittenPCScore	Pearson Correlation	.069	-.014	.022	-.039	-.064
	Sig. (2-tailed)	.505	.894	.836	.710	.536
	N	95	95	95	95	95
InstructorRating	Pearson Correlation	.159	.125	.133	.134	.122
	Sig. (2-tailed)	.126	.230	.202	.197	.242
	N	94	94	94	94	94

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

		AFQT	Needforcognition	Extraversion	Intellect
AGE	Pearson Correlation	-.210*	.017	-.264**	-.140
	Sig. (2-tailed)	.048	.869	.010	.175
	N	89	95	95	95
ADMIN	Pearson Correlation	.923**	.138	.063	.378**
	Sig. (2-tailed)	.000	.182	.544	.000
	N	89	95	95	95
MECH	Pearson Correlation	.690**	.021	-.123	.201
	Sig. (2-tailed)	.000	.840	.236	.051
	N	89	95	95	95
GEN	Pearson Correlation	.882**	.115	.049	.402**
	Sig. (2-tailed)	.000	.267	.635	.000
	N	89	95	95	95
ELECT	Pearson Correlation	.784**	.120	.002	.327**
	Sig. (2-tailed)	.000	.247	.984	.001
	N	89	95	95	95
AFQT	Pearson Correlation	1	.141	.080	.393**
	Sig. (2-tailed)		.187	.457	.000
	N	89	89	89	89
Needforcognition	Pearson Correlation	.141	1	.142	.420**
	Sig. (2-tailed)	.187		.169	.000
	N	89	95	95	95
Extraversion	Pearson Correlation	.080	.142	1	.522**
	Sig. (2-tailed)	.457	.169		.000
	N	89	95	95	95
Intellect	Pearson Correlation	.393**	.420**	.522**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	89	95	95	95
LearningPreference	Pearson Correlation	-.054	-.115	.033	.005
	Sig. (2-tailed)	.660	.324	.778	.967
	N	69	75	75	75
Block2test	Pearson Correlation	.162	.084	.058	.101
	Sig. (2-tailed)	.129	.419	.578	.328
	N	89	95	95	95
WrittenPCScore	Pearson Correlation	-.117	-.053	-.251*	-.047
	Sig. (2-tailed)	.275	.608	.014	.649
	N	89	95	95	95
InstructorRating	Pearson Correlation	.147	.095	-.158	.131
	Sig. (2-tailed)	.171	.361	.129	.208
	N	88	94	94	94

		Learning Preference	Block2test	Written PCScore	Instructor Rating
AGE	Pearson Correlation	.040	.156	.069	.159
	Sig. (2-tailed)	.731	.130	.505	.126
	N	75	95	95	94
ADMIN	Pearson Correlation	-.067	.051	-.014	.125
	Sig. (2-tailed)	.568	.625	.894	.230
	N	75	95	95	94
MECH	Pearson Correlation	-.159	.225*	.022	.133
	Sig. (2-tailed)	.172	.028	.836	.202
	N	75	95	95	94
GEN	Pearson Correlation	-.062	.157	-.039	.134
	Sig. (2-tailed)	.599	.129	.710	.197
	N	75	95	95	94
ELECT	Pearson Correlation	-.131	.080	-.064	.122
	Sig. (2-tailed)	.262	.443	.536	.242
	N	75	95	95	94
AFQT	Pearson Correlation	-.054	.162	-.117	.147
	Sig. (2-tailed)	.660	.129	.275	.171
	N	69	89	89	88
Needforcognition	Pearson Correlation	-.115	.084	-.053	.095
	Sig. (2-tailed)	.324	.419	.608	.361
	N	75	95	95	94
Extraversion	Pearson Correlation	.033	.058	-.251*	-.158
	Sig. (2-tailed)	.778	.578	.014	.129
	N	75	95	95	94
Intellect	Pearson Correlation	.006	.101	-.047	.131
	Sig. (2-tailed)	.957	.328	.649	.208
	N	75	95	95	94
LearningPreference	Pearson Correlation	1	-.112	.062	.050
	Sig. (2-tailed)		.338	.600	.670
	N	75	75	75	74
Block2test	Pearson Correlation	-.112	1	-.051	.384**
	Sig. (2-tailed)	.338		.623	.000
	N	75	95	95	94
WrittenPCScore	Pearson Correlation	.062	-.051	1	.289**
	Sig. (2-tailed)	.600	.623		.005
	N	75	95	95	94
InstructorRating	Pearson Correlation	.050	.384**	.289**	1
	Sig. (2-tailed)	.670	.000	.005	
	N	74	94	94	94

Correlations

It appears from the correlations table above that as age increases, AFQT and ADMIN scores decrease-the younger troops score higher. Younger students would have recently completed high school and thus are likely to still be relatively sharp in a learning sense.

It is no surprise that those students with higher mechanical scores on the ASVAB scored higher on the final exam; this is further validation of the ASVAB test. Those responsible for assigning professions to new enlistees can indeed use the mechanical scores as a means to place troops. Each of the correlations between the different parts of the ASVAB appears to be showing strong correlation. This indicates a general intelligence that seems to prevail over the entire test. If each score is correlated, the tester who does well on one part of the test will most likely achieve high scores on all parts of the test. In this sense, one would presume it difficult to make a judgment as to which nature of employment to place an individual. However, since the scores aren't perfectly correlated, some distinction is possible among enlisted recruits making the test useful.

Another interesting result is that as students increased in age, a significant decrease in extraversion was observed. As students age, they are less likely to be social and outgoing. Additionally, as the need for cognition increased (the desire to learn), intellect significantly increased. Those students who desired to learn more indeed did achieve higher intellect. Finally, instructor ratings were correlated with each of the measures of performance for the course. The instructors did a good job of rating individual competency during the course. In the next section, we examine the use of advanced technical training aids and their effects on student performance.

Technical Training Aid Analysis Results

The fabricators of the enhanced software program claim benefits such as increased learning and heightened knowledge of the maintenance required on the vehicle. Interestingly, test scores and independent performance evaluations paint a different picture. Table 6 shows justification that the scores using the new instruction program are in fact statistically identical to the scores using previous methods of instruction. For simplicity, prior method of instruction using the paper schematic is referred to as Method I while the new computer instruction method is Method II. The point estimate used from the independent samples is the sample mean, $\bar{x}$, an estimate of the true mean $\mu_{\bar{x}}$.

The measures of performance used to compare instruction Methods I and II include a written performance check score, the final test score, and an instructor rating of the overall competency of the student. The written performance check is given midway through the two week course giving the instructors an idea of student comprehension of the material. The final test score is given at the end of the course and is comprehensive in nature. Following the course, the instructor evaluates each student based on observations during the course and assigns a comprehension rating between 1 and 10, 1 being poor and 10 being excellent.

The original claim states this improved training technique will increase student performance and understanding. Since the null hypothesis must contain equality, $H_0 : \mu_1 = \mu_2$, and the original claim is $H_1 : \mu_1 \neq \mu_2$. The probability of making the mistake of rejecting the null hypothesis when it is true is set at $\alpha = .01$, this is the significance level. Thus the z statistic in Table 6 must be less than -2.575 if an increase in knowledge exists and above 2.575 a decrease in knowledge can be declared due to the enhanced training aid.

β – Performance Check Scores
τ – Final Test Scores
δ – Instructor Rating

Table 6

	$\overline{X}$	$\overline{S}$	n	z	Result
β_1	85.70	13.73	121	-.03	Fail to reject $H_0 : \beta_1 = \beta_2$
β_2	85.76	9.69	33		
τ_1	87.24	9.61	76	.54	Fail to reject $I_0 : \tau_1 = \tau_2$
τ_2	85.82	8.38	79		
δ_1	6.81	1.68	86	-1.02	Fail to reject $J_0 : \delta_1 = \delta_2$
δ_2	7.07	1.15	44		

The point estimates of the performance check scores, test scores, and instructor ratings are similar, thus resulting in a z statistic that fails to fall in the critical region. A slight decrease in final test scores was observed, but not enough to declare statistical significance. Conversely, a slight increase in instructor rating occurred under the new method, yet not enough to be establish statistical significance. With mathematical surety, we claim the enhanced training technique fails to increase mechanical knowledge on the Global Deicer as measured by test scores and instructor ratings. Interestingly enough, prior to implementation of the new tool, students were polled to determine whether they felt a tool of this type would allow them to learn the schematics better. Of the students polled, 60% felt a computerized tool would increase their ability to learn the schematic, 21% thought a computerized tool would not help, and 19% were unsure. Additionally, 55% of the students felt this type of tool would increase their performance during parts of the course, 18% felt it would not increase performance, and 27% were unsure. There seems to be a common belief among young students that computerized teaching methods are better than traditional methods. This may be more of a 21st century preference than anything else. As demonstrated in the above analysis, a computerized tool did not change performance metrics. The students polled after implementation of the new tool slightly agreed (4.8 average on a 7 point scale) that the tool did make it easier for them to learn the schematic.

Conclusions/Recommendations

The importance of properly training our airmen cannot be ignored if we are to continue as the world's most respected Air Force. Understanding the vehicle maintenance students' learning preferences allows the instructors to better equip their students with the material they need to perform at the highest possible levels. This is especially true for the kinesthetic learners in this maintenance course.

The relationships between the variables collected and course performance allow the instructors to preemptively spot students who may be potentially poor performers, and implement additional measures to assist them during the course. Since the learning preferences for the majority of the students are kinesthetic and read/write, the instruction should include more time working with the vehicle using the technical manuals. Additionally, the students should be pushed to summarize in writing what they've learned.

Younger or older students with low mechanical ASVAB scores and a visual learning preference may be at a disadvantage when entering the course. Accordingly, middle age students with high mechanical ASVAB scores and a kinesthetic learning preference could be matched up with these "at risk" students as learning buddies. If study groups or teams are used during the course, it would be beneficial to mix different age groups so that relatively younger or older students can leverage study habits of the medium age group. This could possibly decrease the wash-back rate and increase efficiency in the training environment.

The new computerized learning tool doesn't appear to have any effect on student performance indicating that more traditional methods of instruction may be just as effective in certain areas of education. Thus, there is no reason to replace traditional instruction methods (i.e. paper schematics). If the new tool is being used in the field as a job aide, it may; however, be beneficial to learn the tool while in school to allow easy transition to the field. Finally, there may be other benefits not examined in this paper that warrant the implementation of the tool.

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An Assessment of the "Diploma in Computer Engineering" Course in the Technical Education System in Nepal

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Abstract

The purpose of this study was to asses the Diploma in Computer Engineering (DCE) courses offered at affiliated schools of the Council for Technical Education and Vocational Training (CTEVT) with a focus on the goals of the curriculum and employment opportunities. Document analysis, questionnaires, focus group discussions and semi-structured interviews were conducted to gather the data. This study analyzed and described current issues and future policy strategies associated with employment opportunities of graduates. The study indicates that there is potentiality for job opportunities in foreign and domestic markets, especially for DCE graduates. The study also reveals that a remarkable number of graduates are self employed. Based on the findings of the study, the government of Nepal can play a vital role through the CTEVT to improve the employability of DCE graduates by the monitoring and supervision of institutions, fulfillment of standards requirements of programs, curriculum amendment, and marketing DCE programs.

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Background

It is believed that education has a fundamental role to play in personal and social development to reduce poverty, exclusion, ignorance, oppression and war (Delors, 1998). The biggest and most important resource for the economic development of any country is its human resources. With this function, technical education and vocational training has the power to influence the industrial and economic growth of the country. Most of the developed countries give emphasis to human resource development through technical and vocational education at the secondary and higher level within their education system. But in a country like Nepal, where not only 46% of the population is illiterate, but those who are "literate" do not posses the technical skills required to run a modern day efficient economy. Poverty and the inability to earn or produce enough to support oneself or a family are major reasons behind the movement of work seekers from one place to another (Bhattarai, 2005). The study has shown that though there is a sizeable mass of unemployed and underemployed technical education and vocational training (TEVT) graduates, at the same time many sectors of the country are facing a critical shortage of trained manpower. What this indicates is a lack of labor market information to inform the decision making process both among governmental and other stakeholders (KC, 2008). Assessment of employment and labor market contributions in Nepal is difficult because self-employment is common and casual wageworkers are numerous. Even the most basic data on employment and the labor force are either lacking or unreliable (Joshi, 2007).

The struggle of Nepali industry to participate in the international market has substantially increased the importance of technical education and vocational training. It is of vital importance for the Nepali economy to train the workforce that will keep up with the current developments, has professional skills and knows the business world well. This trained workforce will help Nepal to follow up the technology which is rapidly-renewed and constantly-developing parallel to the developments in science and technology. It will also enable the Nepali economy to compete with the developing countries in the international market.

According to the Technical Education and Vocational Training Council Act, 1989 (amended in 1993 and 2006), the Council for Technical Education and Vocational Training (CTEVT) is established as an apex body for the purpose of formulating technical education and vocational training (TEVT) policies, coordinating programs, developing, expanding and ensuring quality of TEVT in Nepal. It has the mandate of regulating and upgrading the standard of technical education and vocational training, maintaining coordination among different agencies imparting such training and determining and certifying the standard of skills. Technical Schools under CTEVT intends to improve employment potential of unemployed youths and link the education and employment system. In order to bring these assumptions to reality, it has been realized that there has to be strong linkage between technical schools/institutions and the labor market (Sharma, 1999). The CTEVT has been granting affiliations to more than 250 institutions offering various courses in Technical School Leaving Certificate (TSLC), Diploma/Certificate, and vocational trainings.

The growth of information and communication technologies has significantly influenced the socio-economic progress of several countries. Besides developed countries, developing countries are also taking advantage of emerging technologies to improve their management system, trade and commerce, education, training and extension services. There is no doubt these technologies are rapidly removing the traditional barriers of distance that until now hindered transfer of information, skills, learning resources and expertise from one place to another. Nepal cannot afford to be an exception. Many institutions in Nepal are emerging in this field and offering short term to advanced higher level courses. Diploma in Computer Engineering (DCE) courses in CTEVT affiliated institutions started in 2001. It is obvious that there is a big demand for computer and information technology professionals and skilled human resources in Nepal. The increasing craze on the computer and information technology sector of Nepal is attracting young adults. Attractive income and boundless opportunity is the main reason that youngsters are running after computer and information technology courses. No single study measuring the volume and depth of employment possibilities has been conducted yet to explore the overall dynamics of employment. Computer courses with information technology are still in primary stages of development in Nepal. Only 37% (CBS, 2004) of the people have access to electricity. In this context, wide use of computers and their access to rural people might take several years. There are many courses related to computer and information technology offered by different institutions in Nepal. Some are affiliated with CTEVT and some are not. The courses range from basic level training to advance degree level. Many students have been studying abroad as well. A study on employment possibilities of DCE graduates from CTEVT affiliated institutions has not been made yet. Therefore, this study was an attempt to explore the information of opportunity to the graduates of diploma courses run by CTEVT affiliated institutions.

In Nepal, primary school starts from grade one to five years of education followed by three years of lower secondary, two years of secondary and two years of higher secondary.

The students graduate from secondary school (10 years), attend one of the schools of general education (higher secondary) or technical education at the technical school leaving certificate (TSLC) or diploma level. They are free to select any system but must successfully pass the entrance exam organized by the individual institutions. The basic goal of general education is to prepare students for academic higher education, as given in higher secondary school affiliated by Higher Secondary Education Council. The basic goal of technical-vocational education is to prepare students for jobs and for four-year technical colleges in higher education, as given in technical colleges or universities. Those who want to attend higher education institutions are required to be successful in the entrance exam organized by related universities. TSLC and Diploma courses are being run by CTEVT and private institutions affiliated by CTEVT. TSLC is a 15 month program and Diploma is 3 years of courses after completion of secondary school. These courses are relatively new and developed by CTEVT. Its compatibility with market demands might be of interest to all concerned students, teachers, professionals, institutions and CTEVT.

Computer education, including information and communication technology, is one of the most saleable courses in the world. Various courses related to computer and information technology have been offered in Nepal ranging from basic training to higher advanced degrees. This study identified employment status of DCE graduates, issues related with level and types of computer professionals most demanded in the market, and content of curriculum. This study analyzed and described current issues encountered by DCE graduates of Nepal and suggests future policy strategies to resolve these issues. The study also explores various types of demand of computer and information technology professionals in the market and collects feedback and comments for making prevailing curriculum more saleable in the market.

The connections between employment and training have always been a problem for the TEVT system in Nepal. The analysis of issues affecting successful transition from training to work provides valuable input for the program planners and curriculum developers to design and implement market-driven computer and information technology programs. In addition, this research builds a foundation for identifying the most prominent problems affecting employment opportunities. It is hoped that outcomes of this study will result in the development of more meaningful DCE curriculum that addresses the employment needs of the Nepalese people.

Purpose

The aim of this study was to assess the employment opportunities of the DCE course graduate. There are three reasons for choosing this program to assess. The first reason is that information and communication technologies have become more widespread. In this fast developing world, it is highly important to train a qualified workforce in Nepal to reach a dynamic, competitive and economic structure. Second, this curriculum is one of the curricula developed and implemented by CTEVT. Therefore, the implementation of this curriculum serves as an example for other curricula. Third, because of high interest of youth, and demand in business and industry for qualified computer technicians.

In the scope of this study, the aim was to answer the following questions:

1. What are the potential areas of employment for DCE graduates?

2. To increase existing employment situation of DCE graduates, what amendments should be incorporated in prevailing DCE courses?
3. To make DCE courses more relevant to the market need, what actions should be taken?

Methods

The procedure followed to achieve the set objectives of the study was a combination of literature review, questionnaire, focused group discussion and semi-structured interviews with the computer and information technology professional, teachers and principals of computer institutions, graduates of DCE, members of Computer Association of Nepal (CAN), entrepreneurs and other similar organizations. Primary information on the issues was taken with the help of an in-depth interview with the experts and the person working on computer and information technology. Some open questions were asked to get their inputs in this research. Informal discussions were also held with the experts and concerned individuals to obtain detailed information about the topic.

Sample

All technical institutes affiliated with CTEVT offering DCE courses since 2001 and the graduates from these institutes were considered as universe for this study. Apart from these, the study covered computer experts and professionals, entrepreneurs and industrialists, and corporate organizations as well. CTEVT affiliated institutes were Lumbini Engineering College (LEC), Sunsari Technical School (STS), Pokhara Engineering College (PEC), Kathmandu Institute of Technology (KIT) and Birganja Institute of Technology (BIT). Altogether 246 students passed through these five institutes until October 2006. Questionnaires were sent only to those graduates who had full addresses with their respective institutes. Out of 246 graduates 210 were correspondent and sent the questionnaire for the study. Among them only 70 (33.33%) graduates responded and were considered as sample for the study.

Table 1 shows the distribution of graduates and sample population by institutes based on the address availability for correspondence.

Table 1

Number of Graduates and Sample Population by Institutes

Institute	**Total No. Graduates**	**Graduates having addresses**	**Replied**
Lumbini Engineering College	82	71	24
Sunsari Technical School	54	48	10
Pokhara Engineering College	45	38	12
Kathmandu Institute of Technology	32	24	7
Birganja Institute of Technology	33	29	17
TOTAL	**246**	**210**	**70**

Besides the use of questionnaires with DCE graduates, focus group discussion (FGD) and semi-structured interviews were also carried out to collect qualitative data. For this purpose non probability incidental sampling method was adopted. FGDs were held in Pokhara, Janakpur, Dhanagadhi and Dharan. Semi-structured interviews were carried out in Kathmandu, Nepalganja and Birganja. Members of professional organizations, computer professionals, entrepreneurs, teachers and managers were key informants. Turn out for both events was 51.

Data collection

Questionnaire survey method was used for quantitative information and focus group discussion and semi-structured interviews were used for getting qualitative information.

1) Questionnaire Survey

The questionnaire was basically designed to be asked to students who graduated from institutions affiliated with CTEVT. Altogether there were eight fixed, closed and four open ended questions relating to employment, income, employer satisfaction, nature of work preferences, future plans, potential area of employment, amendments in curriculum, government effort to improve employment, etc. It was difficult to meet with the DCE graduates directly to get responses because of the nature of their employment and various places of work. Questionnaires were sent through post and to some extent direct contact, and requested them to send the response directly to CTEVT. Therefore, it was difficult to verify the questions and answers.

2) Semi-Structured Interview (SSI)

Open ended questions were developed to conduct semi-structured interviews to computer professionals, entrepreneurs, and industrialists in corporate organizations. The interview basically focused on competencies, current employment status and employment conditions of DCE graduates, as well as the level of need for the computer and information technology workforce, curriculum development, job opportunities and suggestions for improve employability of CTEVT diploma holders. This interview was administered with 16 respondents of computer and information technology fields such as managers, teachers, entrepreneurs, and members of professional associations.

3) Focus Group Discussion (FGD)

For the qualitative information a check list containing major issues to be investigated was developed and implemented through focus group discussions. The discussion focused on the DCE graduate working area, employment conditions, strengths and weaknesses. The group also discussed the curriculum, existing quality of the product, and gave suggestions to CTEVT and the government for immediate action. It was conducted in Janakpur, Dhangadhi, Dharan, Pokhara, and Nepalganja. Altogether there were 51 participants who provided their valuable opinion for the study.

Data Processing and Analysis

All the data collected through different sources was first thoroughly checked, processed and analyzed by classifying/tabulating them in different categories. Further analysis was done using descriptive methods and some analytical methods.

Limitation of the Study

Graduates from different institutes were scattered all over the country, therefore the study completely relied on their responses through correspondence. Most of them probably were outside their residence engaging in jobs and in other business so that only one third portion of the questionnaires was returned. However, attempts had been made to meet DCE graduates during the field survey and a few questionnaires were filled at that time too. Some institutions did not keep all the home addresses of their graduates which also attributed to a relatively small rate of return.

Findings

All together there were 70 graduates from five institutes to respond to the questions raised about the different issues. The respondents who passed DCE courses from 2004-2006 October were taken under study. They responded from diverse geography, culture, family background caste, etc. Out of 70 respondents, 79% were male and 21% were female.

The number of graduate participants by various institutions is shown in Table 2. Similarly, 51 key informants from different computer institutes and colleges, chambers of commerce and industry of Dhanagadhi, Nepalganja, Janakpur, and Pokhara were taken for focus group discussion and semi-structured interviews.

Table 2
Number of Graduate Participated in study by various institutions offering DCE course

Institute	**No. of students**	**Percentage (%)**
Lumbini Engineering College	24	34.3
Sunsari Technical School	10	14.3
Pokhara Engineering College	12	7.1
Kathmandu Institute of Technology	7	10
Birganja Institute of Technology	17	24.3
Total	**70**	**100**

Employment

The employment status of students graduated from CTEVT affiliated institutes is presented in Table 3. Out of 70 students surveyed, the majority of them (54.2%) were found to be employed in different places, while 37% were found to be unemployed and 8.6% were engaged in higher study. Among surveyed students 21% were female and 66% had completed their DCE courses at least 2 years ago as presented in Table 4.

Table 3 - *Employment status of DCE graduates*

Status	No. of student	Percentage (%)
Employed	25	35.7
Self-employed	8	11.4
Foreign employment	5	7.1
Higher study	6	8.6
Unemployed	26	37.1
Total	**70**	**100**

Table 4
Number of surveyed students by number of years completed after taking DCE course

No. of years Completed	No. of students	Female	Male
Less than 1 year	24 (34.3%)	6 (8.5%)	18 (25.7%)
1-3 year	30 (42.9%)	3 (4.3%)	27 (38.6%)
More than 3 years	16 (22.9%)	6 (8.6%)	10 (14.3%)
Total	**70 (100%)**	**15 (21.4%)**	**55 (78.6%)**

Note: Figures within parenthesis show the percentage

Table 4 reveals that most of the respondents completed their DCE course two years before this study. The more the graduation time lags the more the probability of engagement in employment. Those students who were unemployed were asked about their future plan. Out of 32 unemployed graduates, 30% were engaging in higher study whereas 10% still planed to seek a job. Similarly, 5.7% unemployed respondents expressed their view to continue to live as they are presently and 54.28% fell to another category and not related to this query directly as presented in Table 5.

Table 5
Unemployed graduates by their future plan

Future plan	**No. of students**	**Percentage (%)**
Higher study	21	30
Still seeking employment	7	10
Living without doing anything	4	5.7
Not applicable	38	54.2
Total	**70**	**100**

Table 6
Distribution of employed graduates by types of job

Types of job	**No. of students**	**Percentage (%)**
Computer operator	15	39.4
Training (Instructor/Assistant)	8	21.1
Repair and Maintenance	7	18.4
Data entry and Processing	4	10.5
Programmer	2	5.3
Others (Network administration)	2	5.3
Total	38	**100**

According to the participants of the FGD, most of the DCE graduates are working in different fields like a training program, medical transmission, banking, government office, graphics, data base programming, hospitals, business process out-sourcing and departmental stores. A majority of them are in private sector employment. It was found from qualitative discussion that despite low standard curriculum and poor management of institutes, the DCE graduates have high demand in the job market both in country and abroad, particularly in Gulf countries like Malaysia, Thailand and India. Reasons provided behind it were: no high expectations of salary and less conscious to hierarchy and status. The graduates working in different fields are presented in Table 6.

Wedges

The wedges of the DCE graduates range from Rs. 5,000 – Rs. 20,000 per month. The majority of the respondents fall under the category of earnings Rs. 5,000 – Rs. 10,000, whereas only 10% earned between Rs. 15,000 –Rs. 20,000 per month as presented in Table 7.

Table 7

Number of graduate by size of income

Income (Per month)	No. of students	Percentage (%)
Rs. 5,000-10,000	25	65.8
Rs. 10,001-15,000	5	13.2
Rs. 15,001-20,000	4	10.5
No response	4	10.5
Total	**38**	**100**

Employer Satisfaction

The majority of the respondents said that their employers are satisfied with their performance, whereas only 8% were not satisfied with their performance. A small number of respondents (7.9%) could not answer whether their employers are satisfied with their performance or not. It is quite interesting that 24% of the respondents did not like to explore the fact is presented in Table 8. When further asked about the dissatisfaction of their performance, it was personal behavior and inadequate skills of the respondents.

Table 8

Employers' satisfaction by the performance of respondent

Satisfaction of employers	No. of students	Percentage (%)
Yes	23	60.5
No	3	7.90
I don't know	3	7.90
Missing	9	23.7
Total	**38**	**100**

Preference of Employment

The majority of the respondent preferred to get in country office related job where as 17% respondent preferred to go foreign employment. Almost 29% of respondent were found to have their own enterprises. The data is presented in Table 9. It was also found from qualitative response of the respondent that training centers, bank, telecom, government offices, NGO/INGOs and industries are major areas of work.

Table 9

Employment preference by the DCE graduate

Type of Employment	No. of students	Percentage (%)
Within country	38	54.3
Foreign	12	17.1
Self-enterprise	20	28.6
Total	**70**	**100**

Perspective on employment opportunities and Curriculum Development

Perspectives of the DCE graduates and other computer experts and professionals were solicited. Responses were collected through individual correspondence with students and focus group discussions in different places with computer experts and information technology professionals.

Perspective of DCE graduates

Following are views of DCE graduates to improve prevailing employment status:

- Update curriculum as per the need of the market and include individual project work.
- Give more emphasis on practical work and provide more exposure during training.
- Remove unnecessary parts of curriculum and include new topics software design, multimedia, active server pages (ASP), hypertext preprocessor, and virtual places (VP).
- Give authority to individual institutes to include new topics according to current needs of the market.
- Encourage all government offices to use computers for official works and bring an act related with e-documents and computer technology.
- Encourage the private sector for investments to develop hardware and software for computers.
- Give preference to graduates of DCE rather than trainees of short courses for the employment of government services by Public Service Commission (PSC).
- Encourage business and industry people to establish computer industry and information technology parks.

- Conduct regular monitoring/supervision of CTEVT affiliated institutes and improve their standards related with facility and instruction.
- Establish a labor market information system and counseling unit.

Perspective of IT professionals of different institutes

Participants of FGD and SSI expressed their views in connection with research queries related to potential places of employment, improvement in employment opportunity, current trends of employment, curriculum amendments, and government and CTEVT efforts. Following were their suggestions to improve prevailing employment status of DCE graduates:

- Update curriculum regularly as per the need of the market.
- Include electives courses in curriculum to offer courses as per the need of the market.
- Give emphasis on the practical rather than theory and provide more practical exposure during training.
- Include on the job training/Internship in curriculum.
- Create awareness among employers, especially to the government organizations, about the importance of DCE courses.
- Enforce all government offices to keep official documents and information in their computer system.
- Approach the PSC to give preference to DCE graduates rather than short course trainees for government employment.
- Encourage affiliate institutions to maintain guidelines of the courses and standards of facilities through regular monitoring and supervision.

- Include foreign language courses in curriculum as electives.
- Give emphasis to programming language.
- Incorporate all newly emerging computer and information technology in curriculum.
- Develop micro level syllabus for all subjects.
- Define depth of courses clearly and mention sub titles in details.
- Evaluation system of the examination should be improved and questions should represent all chapters based on hours allocated to each chapter.
- Include internship in curriculum instead of the more theoretical part.
- Involve computer experts, professionals and employers at the time of designing new courses and amending curriculum.
- Split existing curriculum in two parts as 2.5 years for institutional teaching and one half year for internship.

Discussion of the Findings

In Nepal there are many computer institutes and colleges who have encompassed courses from basic levels to advanced degrees. Most of the training institutes are registered in the District Administration Office or in the District Domestic and Cottage Industry Office, whereas institutes/colleges offering academic courses have taken affiliation from CTEVT.

Training institutes mostly run short term training and cyber. The majority of surveyed DCE graduates seem to be engaged in such training institutes and cyber as a trainer, manager and entrepreneur. Besides this, graduates are also engaged in foreign and domestic employment as a programmer and networking developer. Facts proved that most of the employers are satisfied with their employees. Though employees were not asked about their satisfaction with their employment during the study, nevertheless most of them were not satisfied because of their job being temporary.

College/schools offering academic courses in the hardware and software programs of computer engineering have not been able to fascinate enough students. Those who have graduated already have not been getting jobs as per their expectation and investment in their study. The paramount reason behind it might be the political situation of Nepal which depleted its economic growth and prosperity in the past decade. Apart from this, government policy is also responsible for not creating conducive environments to develop computer and information technology as an industry. Graduates of higher study have the tendency to go abroad for further study and seeking jobs. However a small portion of surveyed graduates of DCE are looking forward to going abroad or for higher study. Their first preference is in getting job inside their country.

In spite the acceptance of DCE graduates among employers, some factors are hindering a wider opportunity in the job market. Not updating courses as per the market need, below standard training facilities, trainers, inadequate supervision and instruction of CTEVT, lack of recognition of DCE courses by PSC for recruitment in government vacancies are some remarkable facts which make employment situation of DCE graduates harsher.

The present study indicates that there is ample potential for enough job opportunities in foreign markets, especially in Asian countries like Malaysia, Thailand, India and The Gulf. However the graduates should possess a lot of practical exposures in the most recently emerging area of computer and information technology which reflect the needs of the market.

No doubt the government is one of the titanic employers of computer professionals in Nepal. Considering this fact all the respondents of this study emphasize the open door of government positions to DCE graduates through PSC which has been pertained by short term training holder since the last decade. Once PSC recognizes the DCE course for recruitment in government vacancies they will have ample opportunity for employment of DCE graduates.

The study reveals that remarkable numbers of graduates are engaged in self employment too. Those who are not getting jobs at the present are also looking at self employment or taking initiative for entrepreneurship. Self employment does not provide employment to owners only, it also gives jobs to others. Hence it has unseen positive impact in the job market. The field of computer and information technology has been expanding day by day even in remote areas of Nepal. Similarly young people are more attracted towards computers and their applications. This is an encouraging sign for a widening job market of DCE graduate in the future.

It might be a fascinating fact to all that as compared to higher degree and training holders, graduates of DCE courses have a greater demand in the domestic market of Nepal. Studies reveal that two factors favored this fact. DCE graduates did not expect high salaries so they can be adjusted for various job tasks and nature of work. At the same time they did not seem conscious to hierarchy in the working place. Other factors associated with them was their ability to perform a wide range of basic to slightly higher level tasks of computer and networking technology which is not possible to short term training holders.

In spite of immense job opportunity in this sector, only 54% of DCE graduates are employed. This figure did not incorporate the percentage of surveyed students who are looking forward to higher study. If it were not the case it can be interpreted in another way that about 61% were employed. Whatever the percentage of the existing job status of DCE graduates enough room is seen ahead if corrections are made. CTEVT and the government of Nepal are major players to take initiation in this direction.

Conclusion

The information derived from this study will be useful to promote employment opportunity of DCE graduates of CTEVT. The findings of this study will help TEVT planners, curriculum developers and practitioners become aware of the current issues related with the employment opportunity of DCE graduates. Findings also identified strategies for resolving those issues to further improve DCE graduates employment opportunities. Based on the findings of the study CTEVT and government of Nepal can play vital role to improve the employability of DCE graduates in days to come by encouraging its offices to computerize and bring an act related with e-documents and information technology by following necessary steps as prescribed below.

Training institutes/colleges offering DCE courses have not maintained and managed training resources such as teachers, computers, library, books, internet and other physical facilities as prescribed by the guidelines of CTEVT for establishment and affiliation of training institutions. To impart competent workforce laborers, institutes should strictly follow standard guidelines of CTEVT and manage all the essential human and physical resources required for DCE courses.

Most of the trainers are fresh university graduates and are not trained in teaching methodology and have fewer practical skills so that they need to be provided methodology training and practical exposures. CTEVT should monitor and supervise affiliated institutes regularly by professionals' supervisors and take necessary remedial and firing action as per the need. Curriculum should be updated regularly as per the need of the market. Practical work should get more emphasis than theory and students should get more exposure of practical work during training periods. Unnecessary parts of the theory should be omitted and new topics like active server pages, hypertext preprocessor, virtual places, software design and multimedia should be added. There should be some provision of elective courses in curriculum that could be offered in line with local market needs. Curriculum should cover all newly emerged technology in computers and micro syllabus of all subjects with subtitles should be developed in detail. Examination systems should be improved and question patterns should represent all chapters based on hours allocated to each chapter. Existing three years curriculum should be split into two parts as 2.5 years for institutional teaching and half year for internship. There should be provisions of project work for each individual student.

DCE graduates came into the market in 2004 and they can satisfy the need of the middle level computer workforce. Employers (especially government offices) are not aware of the competencies and production of DCE graduates who are far better in all cases as compared to short term training holders. In this regard, CTEVT should approach PSC, ministries, corporate, industries and other potential employers to create position for DCE graduates. PSC should recognize the DCE courses and should stop competition from short term training holders in its examination for the recruitment of vacancies in the Nepal government. The Government of Nepal should encourage the private sector to invest in the development of hardware, software, establish an information technology park, and manufacturing computers and accessories.

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