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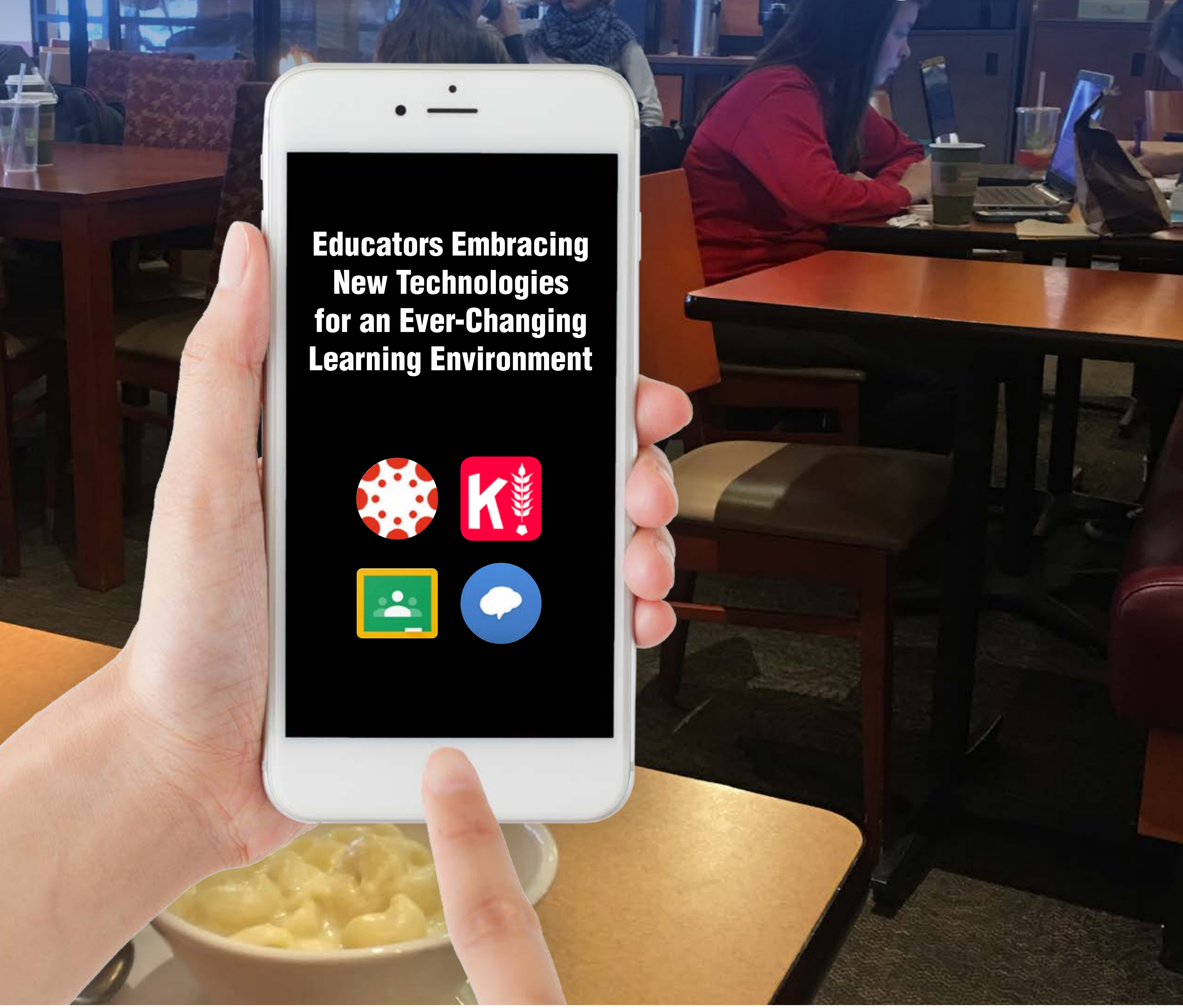

A refereed publication of Epsilon Pi Tau The International Honor Society for Professions in Technology.

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Jerry Streichler, Founding Editor and Publisher from 1977-2006

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Volume XLIII, Number 1, Spring 2017

Effects of Light Intensity on Spatial Visualization Ability

By Petros J. Katsioloudis and Mildred Jones

ABSTRACT

A plethora of technological advances have happened since artificial illumination was developed by Thomas Edison. Like technology has had an effect in many areas in the modern civilization it also made a difference in the classroom. Nowadays, students can have instruction in classrooms with no external windows, even during gloomy winter or rainy days, and virtually during any hour of the day. Several lightning devices are being used, ranging from energy efficient LEDs to fluorescent lighting. Some forms of lighting methods have been found to be inappropriate for prolonged exposure to the human eye such as various gas-discharge lamps that create poorer color rendering due to the yellow light. A large number of research studies have focused on topics such as the effect of light on intensity to oral reading proficiency, its effect on stress levels, and the effect it may have on autistic children. However, a small number of studies was found related to the optimal levels of light intensity related to successful student learning regarding spatial visualization ability. The purpose of the current study is to identify whether light intensity can increase or decrease spatial ability performance for engineering technology students.

Keywords: Light intensity, spatial visualization, engineering technology, technology education

INTRODUCTION AND BACKGROUND

Spatial abilities are essential to success in a variety of fields, including science, technology, engineering, and mathematics (Bogue & Marra 2003; Contero, Company, Saorin, & Naya, 2006; Miller & Halpern, 2013; Mohler, 1997; Sorby, 2009; Sorby, Casey, Veurink, & Dulaney, 2013). Spatial skills are not only fundamental in freshmen engineering coursework, but also they are critical to the success and retention of students in engineering and technology programs. Research suggests that there are positive correlations between spatial ability and retention and completion of engineering and technology degree requirements (Brus, Zhoa, & Jessop, 2004; Mayer, Mautone, & Prothero, 2002; Mayer & Sims, 1994; Sorby, 2009).

Hegarty and Waller (2004) described spatial ability as a collection of cognitive skills which permit the learner to adapt within their environment. Developed through spatial cognition, spatial ability can be explained as the ability to form and retain mental representations of a stimulus mental model, which is used to determine if mental manipulation is possible (Carroll, 1993; Höffler, 2010). This type of ability is also considered an individual ability independent of general intelligence. Literature review supports that individuals with higher spatial abilities have a wider range of strategies to solve spatial tasks and platforms (Gages, 1994; Lajoie, 2003; Orde, 1996; Pak, 2001).

Spatial visualization is often used interchangeably with “spatial ability” and “visualization” (Braukmann, 1991) and involves the mental modification of an object through a series of adjustments, and it is considered a key factor in the success of engineering students (Ferguson, Ball, McDaniel, & Anderson, 2008). According to McGee (1979), spatial visualization is defined as “the ability to mentally manipulate, rotate, twist or invert a pictorially presented stimulus object” (p. 893). In addition, Strong and Smith (2001) suggested a definition as “the ability to manipulate an object in an imaginary 3-D space and create a representation of the object from a new viewpoint” (p. 2). Engineering and technology education researchers, industry representatives, and the U.S. Department of Labor have initiated a need for the enhancement in spatial visualization ability specifically in engineering and technology students (Ferguson, et al., 2008). An enhanced sense of urgency on spatial visualization as a fundamental focus in engineering and technology education has been reported in conference proceedings as well as journal articles over the past two decades (Marunic & Glazar, 2013; Miller & Bertoline, 1991).

Spatial thinking performance in higher education is considered to be the “gatekeeper” to entry and achievement in STEM (Science, Technology, Engineering, Mathematics) studies (Kell, Lubinski, Benbow & Steiger, 2013;

Uttal, Meadow, Tipton, Hand, Alden, Warren & Newcombe, 2013; Newcombe, 2010). Research has suggested that environmental factors may have an impact on spatial ability (Belz & Gear;1984; Harris, 1978; Mann, Sasanuma, Sakuma, & Masaki, 1990; Mohler, 1997; Tracy, 1990).

Light Intensity

Light intensity has always been important for human existence since it greatly influences sleep, alertness, melatonin and cortisol levels, blood pressure, pulse, respiration rates, brain activity and biorhythm (Wurtman, 1975). It is suggested that lighting enhances the overall performance in the workplace (assembly) as well as learning environments (Akbari, Dehghan, Azmoon, & Forouharmajd, 2013). Classroom lightning has been found to be related to student learning in various ways (Winterbottom & Wilkins, 2009). Light intensity is found to be very important for classroom settings for children with autism because their neural system responds in an unusual way to different light intensities and different light sources; especially bothersome is the fluorescent lighting (Menzinger & Jackson, 2009). Student discomfort in the classroom, such as headaches and impaired visual performance have been reported in classrooms with 100 Hz fluorescent lightning in studies that included a sample of 90 schools in United Kingdom (Winterbottom & Wilkins, 2009). In contrast, different negative effects, such as increased stress hormone level in children have been reported in situations where levels of lighting were lower than usual, as during winter months and in classrooms with no windows (Küller & Lindsten, 1992). Light influences melatonin production, and influences student learning (Boyce & Kennaway, 1987).

Teachers have reported that daylight is their preferred lighting setup and they prefer to have control over lights in the classroom (Schreiber, 1996). Although the optimal level of luminescence can be defined, it is hard for the teacher to always enable the optimal lighting condition throughout the day since he or she is focused on teaching and multiple activities, and the position of the sun and weather changes constantly throughout the day (Ho, Chiang, Chou, Chang, & Lee, 2008). For that purpose, building automation systems have developed to enable more efficient and environmentally friendly use of lighting systems in classrooms (Luansheng, Chunxia, Xiumei, & Chongxiao, 2012). Samani and Samani (2012) published a study to determine how learning settings in schools, universities, and colleges can be designed to provide an environment where lighting quality and students' learning performance can be enhanced through lighting intensity (Samani, 2012). According to Hygge and Knez (2001) and Knez (1995), light output and color temperature have an important effect on a person's visual perception, cognition, and mood state (Hygge & Knez, 2001). All of these areas fundamentally influence a person's visual strengths, especially spatial ability. LED lighting in particular offers color temperature flexibility and control over output, as well as a reduction in energy usage (Li, Lu, Wu, & Wang, 2015).

Light Intensity and Visuo-spatial ability

Several neuroimaging studies support the hypothesis of non-visual effects of light on performance by showing that different wavelengths and intensity of light exposure can modify the neural activity in cortical areas as well as in subcortical structures during cognitive tasks (Vandewalle, Maquet, & Dijk, (2009). Neuroimaging studies have also shown light-induced activity in both the prefrontal cortices and parietal lobes (Vandewalle et al., 2009), recognized to be involved in visuo-spatial abilities.

Technological lighting development over the last decade has created the need for more accurate and stringent analyses of their effects on human performance and health (Ferlazzo, Piccardi, Burattini, Barbalace, Giannini, & Bisegna, 2014). Work by (Hawes, Brunyé, Mahoney, Sullivan, & Aall, 2012) compared visual perceptual, affective and cognitive implications of four different luminous scenarios: one fluorescent lighting (3345 K) and three LED lighting (4175 K, 4448 K, 6029 K). Results showed a better performance of 24 volunteers on cognitive tasks with LED sources because reaction times resulted faster with the increase of CCT, and significant improvements were recorded with 4175 K in respect to 3345 K (Ferlazzo, et al., 2014).

Definition of light intensity

For the specific study light intensity is defined as the quantity of visible light that is emitted in unit time per unit solid angle on a specific drafting model. The unit of Lux was used for the study that represents illumination equal to the direct illumination on a surface that is everywhere one meter from a uniform point source of one candle intensity or equal to one lumen per square meter (Lux, 2017). The researcher is assuming that increase of light intensity will remote an increase of visual detail related the drafting model that it will then increase the amount of information transfer to the observer. Higher amount of visual information should allow the learner to better mentally visualize a sectional view of the drafting model.

RESEARCH QUESTION AND HYPOTHESIS

To enhance the body of knowledge related to light intensity for spatial visualization ability, the following study was conducted.

The following was the primary research question:

> *Will different levels of light intensity significantly change the level of spatial visualization ability as measured by the Mental Cutting Test and sectional drawings for engineering technology students?*

The following hypotheses were analyzed in an attempt to find a solution to the research question:

> H_0: *There is no effect on engineering technology students': (a) Spatial visualization ability as measured by the Mental Cutting Test and (b) ability to sketch a sectional view drawing, due to the different levels of light intensity: 250 -500 Lux, 500-750 Lux, and 750-1000 Lux.*

> H_A: *There is an identifiable amount effect on engineering technology students': (a) Spatial visualization ability as measured by the Mental Cutting Test and (b) ability to sketch a sectional view drawing, due to the different levels of light intensity: 250 -500 Lux, 500-750 Lux, and 750-1000 Lux.*

METHODOLOGY

A quasi-experimental study was selected as a means to perform the comparative analysis of spatial visualization ability and lighting during the fall of 2016. Using a convenience sampling process the authors decided that a quasi-experimental method was appropriate for conducting the experiment. The research protocol was generated and submitted for approval to the College's Human Subjects Review Committee where it received exempt status. Using a convenience sample, there was a near equal distribution of participants among the three groups.

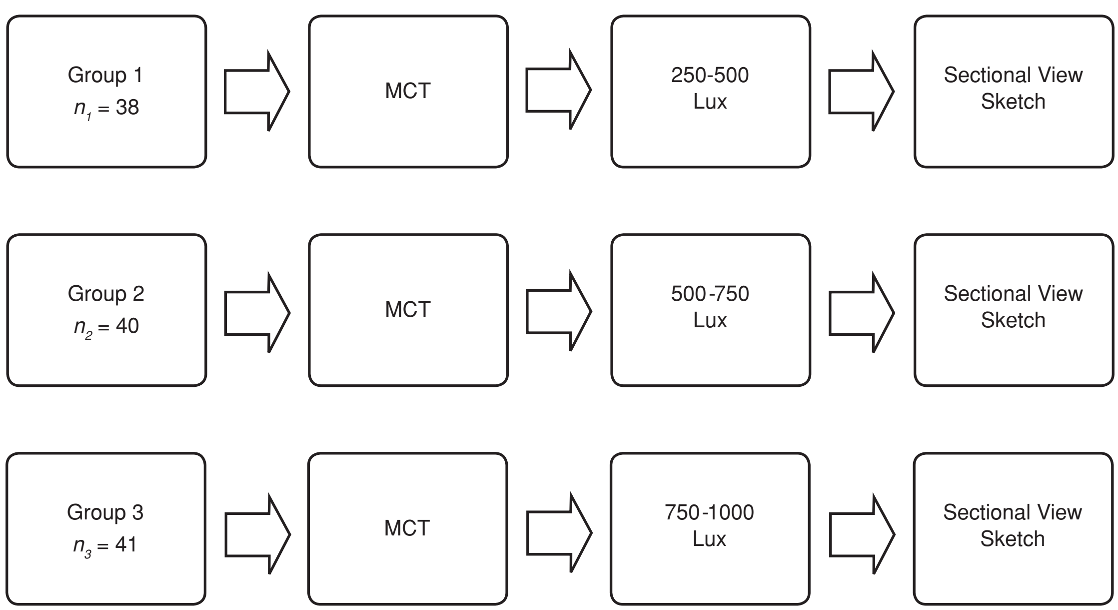

Figure 1: Research Design Methodology

The study was conducted in a 200-level Engineering Graphics course offered as part of the Engineering Technology program. The participants from the study are shown in Figure 1.

The engineering graphics course emphasized hands-on practice using 3-D Autodesk & AutoCAD software in a computer lab, along with the various methods of editing, manipulation, visualization, and presentation of technical drawings. In addition, the course included the basic principles of engineering drawing/hand sketching, dimensions, and tolerance.

The three groups (n_1 = 38, n_2 = 40 and n_3 = 41, with an overall population of N = 119) were presented with a visual representation of an object (visualization). All three groups (n_1, n_2, n_3) received a 3-D printed pentadecagon (see Figure 2) model, and were asked to create a sectional view sketch (see Figure 3) while the model was exposed into three different light intensities for each group, (250-500 lux, 500-750 lux and 750-1000 lux), respectively (see Figure 4). Since light was used as a part of the study treatment, and to prevent bias for students using glasses or contact lenses, all participants were exposed into several light intensities (varying from 250-1000 lux), and they were asked to report whether they could see clearly or not. No students were identified as having difficulty seeing within the spectrum of the lighting conditions used in this experiment.

To establish a baseline and identify spatial visualization ability level, all groups were asked to complete the Mental Cutting Test (MCT) (College Entrance Examination Board [CEEB], 1939) instrument, two days prior to the completion of the sectional view. The MCT was not used to account for spatial visualization skills in this study. The only purpose was to establish a near to equal group dynamic based on visual ability, as it relates to Mental Cutting ability. According to Nemeth and Hoffman (2006), the MCT (CEEB, 1939) has been widely used in all age groups, making it a good choice for a well-rounded visual ability test. Compared to other spatial tests measuring spatial visualization ability, the MCT problems are solved by looking at a visually presented stimuli and subjects have to mentally produce solutions (Quaiser-Pohl, 2003). In addition, the fact that there is no visually presented stimuli, the problems also cannot be solved by just reasoning, which it makes MCT an appropriate instrument to be used for this study.

The Standard MCT consists of 25 problems. The Mental Cutting Test is a subset of the CEEB Special Aptitude Test in Spatial Relations and has also been used by Suzuki (2004) to measure spatial abilities in relation to graphics curricula (Tsutsumi, 2004). As part of the MCT test, subjects were given a perspective drawing of a test solid, which was to be cut with a hypothetical cutting plane.

According to Quasier-Pohl (2003), for the MCT test, subjects have to mentally cut three-dimensional geometrical figures (e.g., pyramids, cones) that are hollow. Examples include a sphere that after the cut it results into a circular

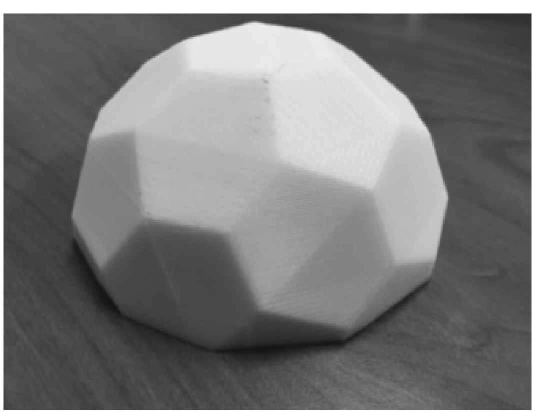

Figure 2: The model for all groups was a 3D printed pentadecagon

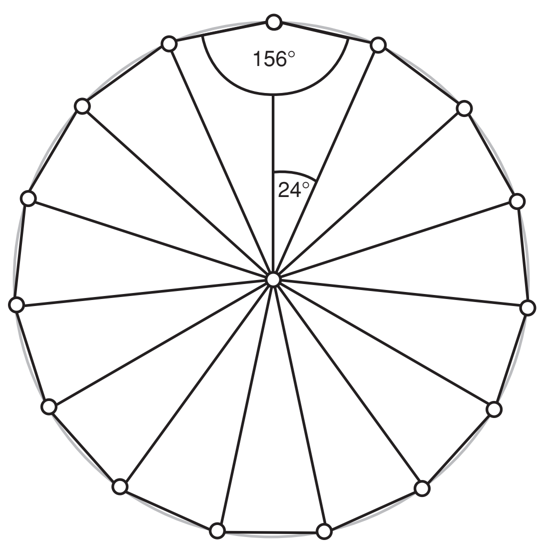

Figure 3: Sectional views of the pentadecagon 3D printed model (Németh, 2013)

Figure 4: Photometer used to measure ambient light for the three treatments

shape. More complex forms could also be used that result from cutting more complex geometrical shapes such as the pentadecagon used in this study (Quaiser-Pohl, 2003). For the specific study, the researcher considered student experiences as they related to academic background (engineering technology students that have completed the first 100-level engineering graphics course and were enrolled in the 200 level). Additional external student abilities or experiences were not considered for the specific study because the author believed this could be addressed at a different study in the future.

Subjects were then asked to choose one correct cross section from among five alternatives. There were two categories of problems in the test (Tsutsumi, 2004). Those in the first category are called *pattern recognition problems*, in which the correct answer is determined by identifying only the pattern of the section. The others are called *quantity problems*, or *dimension specification problem*s, in which the correct answer is determined by identifying, not only the correct pattern, but also the quantity in the section (e.g., the length of the edges or the angles between the edges) (Tsutsumi, 2004).

Upon completion of the MCT, the instructor of the course placed identical models of the dynamic 3-D pentadecagon for groups n_1, n_2 and n_3 in a central location in three different classrooms. The three groups were asked to create a sectional view of the pentadecagon (see Figure 3). Sectional views are very useful engineering graphics tools, especially for parts that have complex interior geometry, as the sections are used to clarify the interior construction of a part that cannot be clearly described by hidden lines in exterior views (Plantenberg, 2013). By taking an imaginary cut through the object and removing a portion of the inside, features could be seen more clearly. Students had to mentally discard the unwanted portion of the part and draw the remaining part. The rubric used included the following parts: (a) use of section view labels, (b) use of correct hatching style for cut materials, (c) accurate indication of cutting plane (d) appropriate use of cutting plane lines, and € appropriate drawing of omitted hidden features. The maximum score for the drawing was 6 points. This process takes into consideration that research indicates a learner's visualization ability, and level of proficiency can easily be determined through sketching and drawing techniques (Contero et al., 2006; Mohler, 1997). All students in all groups were able to approach the visualization and observe it from a close range.

DATA AND ANALYSIS

Analysis of MCT Scores

The first method of data collection involved the completion of the MCT instrument prior to the treatment to determine equality of spatial ability between the three different groups. The researchers scored the MCT instrument, as described in the guidelines by the MCT creators. A standard paper-pencil MCT pre-and-post were conducted, in which the subjects were instructed to draw intersecting lines on the surface of a test solid with a green pencil before selecting alternatives. The maximum score that could be received on the MCT was 25. As it can be seen in Table 1 the group scores were very close with no significant difference.

Due to the abnormality of the population (convenience sample), a non-parametric Kruskal-Wallis test was run to compare the mean scores for significant differences, as it relates to spatial skills among the three groups. The result of the Kruskal-Wallis test, as shown in Table 2, was not significant $X^2 = 1.012$, $p < 0.230$. Data were tested for equality of variances using Levene's test. Levene's test indicated equal variances ($F = 2.28$, $p = .234$); therefore, degrees of freedom did not have to be adjusted.

Analysis of Drawing

The second method of data collection involved the creation of a sectional view sketch drawing. As shown in Table 3, the group that worked in 500-750 Lux lighting conditions ($n = 40$), had a mean observation score of 3.944. The groups that were exposed to 250-500 Lux ($n = 38$) and 750-1000 Lux ($n = 41$) had lower scores of 3.924 and 3.032, respectively (see Table. 3). A Kruskal-Wallis test was run to compare the mean scores for significant differences among the three groups. The result of the Kruskal-Wallis test, as shown in Table 4, was significant: $X^2 = 1.432$, $p < 0.0036$. Data were dissected further through the use of a post hoc Steel-Dwass test. As it can be seen in Table 5, the post hoc analysis shows a statistically significant difference between the 550 vs. 750 Lux ($p < 0.057$, $d = 0.203$, $Z = 2.8234$) and the 750 vs. 1000 Lux ($p = 0.002$, $d = 0.394$, $Z = 2.4242$).

TABLE 1: MCT Descriptive Results

Light Intensity [Lux]	*N*	*Mean pre-test*	*Mean post-test*	*SD pre-post*	*SE pre-post*	*95% Confidence Interval for Mean Lower Bound pre-post*	*95% Confidence Interval for Mean Upper Bound pre-post*
250-500	38	23.839	24.845	3.374	.893	22.849	23.945
500-750	40	22.947	23.983	3.938	.683	23.209	23.034
750-100	41	22.833	24.093	4.839	1.892	22.908	23.039
Total	119	23.206	24.307	4.050	1.156	22.988	23.339

TABLE 2: MCT pre and post-test Kruskal-Wallis H test Analysis

Light Intensity [Lux]	*N*	*DF*	*Mean Rank*	*X^2*	*p-value*
250-500	38	2	22.529	1.012	0.230
500-750	40		23.932		
750-100	41		24.031		
Total	119				

TABLE 3: Sectional View Drawing Descriptive Results

Light Intensity [Lux]	*N*	*Mean*	*SD*	*Std. Error*	*95% Confidence Interval for Mean Lower Bound*	*95% Confidence Interval for Mean Upper Bound*
250-500	38	3.924	0.692	0.1203	3.928	4.028
500-750	40	3.944	0.502	0.1424	4.392	4.422
750-100	41	3.032	0.532	0.1392	3.782	3.028
Total	119	3.633	0.575	0.1399	3.824	3.826

TABLE 4: Sectional View Kruskal-Wallis H test Analysis

Light Intensity [Lux]	*N*	*DF*	*Mean Rank*	*X^2*	*p-value*
250-500	38	2	22.92	1.432	0.0036*
500-750	40		23.78		
750-100	41		23.998		
Total	119				
* Denotes statistical significance					

TABLE 5: Sectional View Drawing Steel-Dwass test Results

	Light Intensity (1 vs. 2 vs. 3)	*Score Mean Diff.*	*Std. Error*	*Z*	*p-value*
2 vs 1	550 vs. 750 Lux	0.203	0.1673	2.8324	0.057*
2 vs 3	750 vs. 1000 Lux	0.394	0.1725	2.4242	0.002*
3 vs 1	1000 vs. 250 Lux	0.183	0.1783	1.3247	0.310

DISCUSSION

This study was done to determine whether the different levels of light intensity, 250-500 lux, 500-750 lux and 750-1000 lux, significantly change the level of spatial visualization ability, as measured by the MCT and sectional drawings for engineering technology students. It was found that the different levels of light intensity provided statistically significant higher scores; therefore, the hypothesis that there is an identifiable amount of effect on engineering technology students': (a) Spatial visualization ability as measured by the MCT and (b) ability to sketch a sectional view drawing, due to the different levels of light intensity: 250-500 Lux, 500-750 Lux and 750-100 Lux, was accepted.

The fact that two of the groups gained a statistically significant advantage when exposing the drafting model in different levels of light intensity could suggest that important details on the drafting model can be hidden during lower light conditions. Previous studies suggested positive correlation between lighting levels and oral reading fluency performance among middle schools students and learning in general (Mott, Robinson, Walden, Burnette, & Rutherford, 2012). In addition, a review of literature supports that color and light intensity have positive effect on cognitive performance, and the level varies across different groups such as female or male students (Knez, 1995).

The results of this pilot quasi-experimental study suggest that lighting conditions affect learning in different ways. It is suggested that if a specific spectrum of light (250 Lux up to 1000 Lux) could aid learning, the following question arises: Since specific lighting conditions seem to promote and enhance learning abilities, why are these not offered at all schools? Löfberg (1970) states that adequate lighting level might be hard to obtain since many schools and universities are focusing on cost savings and more environmentally friendly use of electrical energy. Some schools in different countries are limiting time that the artificial light is used in the classroom due to the energy cost (Ho et al., 2008). Moreover, the problem of adequate lighting setup is also related to many variables, such as classroom location, classroom shape, direction of light at different points, distribution of luminance in the student's field of vision, and so on (Löfberg, 1970). The cost of energy is especially important in warmer climates and it affects the choice of lighting schemes along with sun shades, both of which are found to be optimal for the classroom (Ho et al., 2008).

Limitations and Future Plans

In order to have a more thorough understanding of the effects on spatial visualization ability and light intensity for engineering technology students, it is important to consider further research. Future plans include, but are not limited to:

- Repeating the study using a larger population to verify the results.
- Repeating the study using a different population, such as mathematics education, science education, or technology education students.
- Repeating the study by comparing male versus female students.

Dr. Petros J. Katsioloudis *is Associate Professor and Chair of the STEM Education and Professional Studies Department at Old Dominion University, Norfolk, Virginia. He is a Member-at-large of Epsilon Pi Tau.*

Ms. Mildred Jones *is a Graduate Student in the Department of STEM Education and Professional Studies at Old Dominion University, Norfolk Virginia.*

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Cyber-supported Professional Learning Experiences that Build Technology and Engineering Educators' Practice

By Jeremy Ernst, Aaron Clark, and Sharon Bowers

ABSTRACT

Educational changes due to school reform and the introduction of new national standards create a need for professional learning experiences for STEM (Science, Technology, Engineering, and Mathematics) educators that are results-driven, easily accessible, and aligned with identified best practices (National Research Council, 2009; National Staff Development Council, 2001). This need, specifically addressing technology and engineering educators, generated the development and delivery of the *Transforming Teaching through Implementing Inquiry* (T2I2) project. Within the T2I2 development stage, learning objects were created to introduce, reinforce, and broaden technology and engineering educators' conceptual content and pedagogical content knowledge to inform and impact their personal teaching practice. To deliver this instruction, a cyber infrastructure was created to support content development, assessment, community building, and cyber-coaching.

This field study followed the methodology established within T2I2's two-year pilot study (Ernst, Segedin, Clark, & DeLuca, 2014), selecting participants from the identified five-state region (IL, KY, OH, NC, and VA) and requiring these participants to complete T2I2 learning objects and accompanying written and video artifacts. Submitted artifacts were analyzed using the non-parametric Wilcoxon-signed-ranks Test, providing evidence that suggested that the field study teachers demonstrated proficient abilities to contribute to a learning community; manage, monitor, and adjust learning environments, and increase their self-assessment. The combined pilot and field test studies provide evidence to support expanding the development and use of the T2I2 model for science educators for a more interdisciplinary approach to STEM professional learning experiences.

keywords: teacher learning, technology and engineering education, web-based professional development

INTRODUCTION

In this era of school reform and new national standards, professional development for educators is a key factor in building teacher confidence and competences (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009). National STEM education initiatives cite the need and importance of professional learning opportunities for Science, Technology, Engineering, and Mathematics (STEM) educators, but the instructional support offered to these educators varies in quality and effectiveness (National Research Council [NRC], 2009). Professional learning experiences for technology and engineering teachers are often found to be deficient and less robust than professional development for teachers in other STEM disciplines (DuBois, Farmer, Gomez, Messner, & Silva, 2009; Li, Ernst, & Williams, 2015; National Academy of Engineering & NRC, 2009). The lack of effective professional development for technology and engineering educators is further accentuated by a shortage of licensed and certified teachers for this discipline (National Board for Professional Teaching Standards [NBPTS], personal communication, October 2012). As states adopt the *Next Generation Science Standards* (NGSS), there will be increased demands for professional development for STEM educators to address changes in content and pedagogy that integrate science content with engineering practices and promote inquiry- and design-based teaching and learning (NRC, 2015).

A lack of effective professional development for some and increased needs to shift instruction for all, require the development of and easy access to results-driven, job-embedded professional learning experiences (National Staff Development Council [NSDC], 2001). Professional development that changes teacher practice must build a community of learners and be flexible, practical, and focused on content and strategies that can be immediately implemented within classroom settings (Li et al., 2014; Garet, Porter, Desimone, Birman, & Yoon, 2001; NSDC, 2001; Schlang, 2006;

Weiss & Pasley, 2006). Traditional models of professional development can be costly, time consuming, and often an added burden to teachers' already over-stretched commitments (Dede et al., 2009). Today's educators need professional learning experiences that can merge with existing expectations, incorporate resources that may not be readily accessible, and offer a supportive learning community that provides real-time, continuous, classroom-based support. Professional development provided through an online setting provides this framework for learning and, through asynchronous online discussions, a platform for self-reflection, collaboration, networking, and shared resources (Almendarez-Cadena, 2014; Dede et al., 2009; Zepeda, 2015).

The need for quality and easily accessible professional learning opportunities for technology and engineering educators was the impetus behind the development and delivery of the *Transforming Teaching through Implementing Inquiry* (T2I2) project. T2I2's first goal in addressing this need was to develop learning experiences that reinforced and broadened technology and engineering educators' conceptual understanding, teaching practices, and pedagogical content knowledge. Specific content and practices, identified from *the National Board for Professional Teaching Standards (NBPTS) for Early Adolescence through Young Adulthood (EAYA) Career and Technical Educators,* framed the T2I2 professional learning experiences for secondary technology and engineering educators (Pearson, 2012). The T2I2 structured and practice-driven experiences, known as Learning Objects, encouraged and modeled ways for technology and engineering educators to improve their classroom instruction, participate in professional activities, and increase student learning.

An equally important goal for the T2I2 project was to develop a cyber infrastructure to support the delivery of the newly developed web-based resources and materials. Within this system, documents and teacher artifacts were easily shared. All stakeholders benefited from the system architecture that allowed for easy authoring, publishing, assessment, community building, self-reflection and cyber coaching. Achieving both goals was critical to the success of the T2I2 project.

The instructional design of the T2I2 Learning Objects, paired with the web-based learning environment, resulted in the implementation and delivery of professional development that changed teacher practice (Segedin, Ernst, & Clark, 2013). The T2I2 research supports the premise that effective instructional design and an efficient and effective technical infrastructure can substantially impact the success and acceptance of online learning (Cheawjindakarn, Suwannatthachote & Theeraroungchaisri, 2012).

RESEARCH HYPOTHESES

A two-year field study within the T2I2 project followed a two-year pilot study. The scope and results of the pilot study are described within the article, *Flexible and Job-Embedded Professional Development for In-Service Technology, Design, and Engineering Educators* (Ernst, Clark, & Bowers, 2017). The pilot study was formative in design resulting in revisions and improvements to content within some Learning Objects, self-assessment tools and user features within the cyber infrastructure. The two-year summative field study, informed by the pilot study, provided the setting to verify the effectiveness of both the design materials and delivery infrastructure. Five investigational hypotheses framed both the pilot and field study.

- Research Hypothesis 1: H_0 - A teacher's ability to *manage* learning environments was deemed proficient following the use of the T2I2 professional development materials.
- Research Hypothesis 2: H_0 - A teacher's ability to *monitor* learning environments was deemed proficient following the use of the T2I2 professional development materials.
- Research Hypothesis 3: H_0 - A teacher's ability to *adjust* learning environments was deemed proficient following the use of the T2I2 professional development materials.
- Research Hypothesis 4: H_0 - A teacher's ability to *contribute* to the learning community was deemed proficient following the use of the T2I2 professional development materials.
- Research Hypothesis 5: H_0 - A teacher's ability to *increase self-assessment* was deemed proficient following the use of the T2I2 professional development materials.

Field study teachers paralleled the work of the pilot study teachers. Both groups completed T2I2 professional development modules and responded to the same performance assessments that required the completion of written and video artifacts. The performance assessments and artifacts mirrored the evidence required of teachers applying for National Board *Certification for (EAYA CTE)* and provided insight into the field study teachers' abilities to manage, monitor, and adjust their learning environments; develop reflective self-assessment strategies; and increase contributions to the broader learning community (Pearson, 2012).

STUDY PARTICIPANTS AND METHODOLOGY

The researchers refined and enhanced the learning environment and instructional design of the T2I2 project based upon user feedback and analytic data from the pilot study. Following the protocols within the methodology of the pilot study, middle and high school teachers for two field study groups were recruited from the project's five-state region (Illinois, Kentucky, Ohio, North Carolina, and Virginia). As part of the requirements for participation, none of these teachers held Technology Education National Board certification.

The first field study group was composed of five middle and eight high school teachers (grades 6 - 12). Similar to the pilot group, this field study group agreed to: (1) complete all 18 Learning Objects within the four T2I2 curricular units and (2) to submit written and video artifacts following the completion of each unit.

Six participants, one middle and five high school teachers, were involved in the second field study and agreed to a streamlined task. They were asked to: (1) complete only eight of the 18 Learning Objects within two T2I2 curricular units; and then (2) submit the corresponding written and reflective artifacts. This group's work targeted two units that had major revisions based upon formative feedback from teachers within both the pilot and first field study groups.

The T2I2 Learning Objects addressed topics identified for *EAYA CTE National Board Certification and were originally developed by a team of technology and engineering* Nationally Board Certified teachers, technology and engineering teacher educators, and veteran in-service technology and engineering K-12 educators. Following a uniform design, each Learning Object included (1) a research-informed section addressing each topic's "Impact on Learning"; (2) step-by-step suggestions for implementation in the "Procedures in the Classroom" section and; (3) strategies to check for successful implementation within the "Determine Success" section.

A summative five-question post-assessment quiz was included in each Learning Object to check for the teachers' baseline understanding. Upon the completion of the Learning Objects within each unit, teachers' abilities to apply newly learned practices were demonstrated through written and/or video artifacts. These artifacts provided evidence that addressed the research hypotheses for both the pilot and field studies. All work within T2I2 was asynchronous once participants completed an introductory webinar. This webinar familiarized teachers to the T2I2 website, resources, deadlines, and project goals. Monthly virtual office hours and frequent emails from the researchers offered encouragement and assistance to the field study groups. Each field study followed the academic year, beginning in September and ending by May.

Data collection and analysis for the field study followed the pilot study's methodology. Data was combined from both field study groups, resulting in a sample of 19 educators, and it was analyzed using quantitative research methods. The submitted written and video artifacts were scored by a National Board Certified teacher using a four-point scoring system and modified rubric. Results from this assessment, statistically analyzed using non-parametric procedures, provided data that addressed the five research hypotheses. Teachers' user data, related to the summative post-assessments, and teacher access data, analyzing the time spent on each unit, provided feedback regarding the learning environment.

The initial research approach for the T2I2 project suggested a treatment and control study. Guidance from the sponsoring entity, however, resulted in modifying the original approach and proceeding with the described directional studies for both the pilot and field studies.

INSTRUMENTATION

Following the pilot study's protocol, criterion-referenced metrics of the NBPTS were used to assess and measure the field study teachers' written and video artifacts, providing feedback as to the teachers' abilities to conduct self-assessment, contribute to a learning community, and improve their instruction by managing, monitoring, and adjusting a learning environment. These artifacts reflected teaching practices related to the specific content and pedagogy introduced to the field study group through the T2I2 Learning Objects.

Each of the 18 Learning Objects addressed a particular topic. Learning Objects were grouped into four units based upon common themes and NBPTS assessment criteria. The teacher artifacts were completed and submitted upon the completion of each of the units. Participants within the first field study group were expected to complete all units. This work is organized within Table 1.

TABLE 1: First field study group's artifacts aligned with unit, learning objects, and hypotheses

Artifacts	Unit	Learning Objects	Research Hypotheses
Entry 2.1: Video Capture	Demonstration Lesson	Designing Standards Based STEM; Lab and Class Management; STEM Curricula	Research Hypothesis 1: H_0 - A teacher's ability to *manage* learning environments was deemed proficient following the use of the T2I2 professional development materials.
Entry 2.3: Written Commentary	Demonstration Lesson	Designing Standards Based STEM; Lab and Class Management; STEM Curricula	Research Hypothesis 4: H_0 - A teacher's ability to contribute to the learning community was deemed proficient following the use of the T2I2 professional development materials.
Entry 3.1: Video Capture & Entry 3.3: Written Commentary	Fostering Teamwork	Best Practices; Classroom Quality; Enhancing Classroom Creativity; Implementing Learning Activities; Multiculturalism in the Classroom; Working with Special Populations	Research Hypothesis 2: H_0 - A teacher's ability to *monitor* learning environments was deemed proficient following the use of the T2I2 professional development materials.
Entry 1.4: Written Commentary	Assessment of Student Learning	Action Research; Adapting Instruction; Data Analysis; Formative Evaluation Techniques; Initial Student Evaluation	Research Hypothesis 3: H_0 - A teacher's ability to *adjust* learning environments was deemed proficient following the use of the T2I2 professional development materials.
Entry 4.1: Description and Analysis	Documented Accomplishments	Professional Organizations School and Community; Student Organizations	Research Hypothesis 5: H_0 - A teacher's ability to increase self-assessment was deemed proficient following the use of the T2I2 professional development materials.

Teachers in the second field study group completed only two of the four units, depicted in Table 2. Both tables show the pairing of Learning Objects with artifacts required for each entry and indicate how this evidence matches the research hypotheses.

For statistical analysis, the scoring instances (*n*) varied depending upon the entry, due to the fact that there was a supplemental field study for two of the units. As seen within Table 1, the artifacts submitted upon the completion of all Learning Objects within the Demonstration Lesson Unit provided evidence to address the first and fourth research hypotheses. The artifacts provided for this entry addressed the NBPTS criterion metrics pertaining to explanation and demonstration of progression steps, interaction with students as they perform demonstrated skills, and monitoring performance while providing feedback and addressing student questions.

Completion of the Fostering Teamwork Unit and subsequent written and video entries provided data to address the second research hypothesis. This entry aligns with the NBPTS criterion metrics pertaining to explanation of the specific application in which students are engaged, support of student teamwork and student communication skills, monitoring performance while providing feedback and addressing students' questions.

As seen with Tables 1 and 2, the artifacts submitted upon the completion of all Learning Objects within the Assessment of Student Learning Unit provided evidence regarding teachers' abilities addressed within the third research hypothesis. This entry incorporated NBPTS criterion metrics pertaining to knowledge of students in designing assessments, relation of assessments to course learning goals, problem-solving in assessment design, assessment related to workplace practice and career exploration, and assessment in shaping teaching practices for the purpose of adjusting instruction.

TABLE 2: Second field study group's artifacts aligned with unit, learning objects, and hypotheses

Artifacts	Unit	Learning Objects	Research Hypotheses
Entry 1.4: Written Commentary	Assessment of Student Learning	Action Research; Adapting Instruction; Data Analysis; Formative Evaluation Techniques Initial Student Evaluation	Research Hypothesis 3: H_0 - A teacher's ability to *adjust* learning environments was deemed proficient following the use of the T2I2 professional development materials.
Entry 4.1: Description and Analysis	Documented Accomplishments	Professional Organizations School and Community; Student Organizations	Research Hypothesis 5: H_0 - A teacher's ability to increase self-assessment was deemed proficient following the use of the T2I2 professional development materials.

The fifth research hypothesis was addressed through the assessment of the artifact submitted once both field study groups completed all Learning Objects within the Documented Accomplishments Unit. This entry incorporated NBPTS criterion metrics pertaining to how the teacher had strengthened practice through professional development, shared expertise with others, including within both the education and the community settings, engagement of parents and other adults in communication, and improvement strategies.

All submitted artifacts were reviewed by the same National Board certified assessor using a modified four-point rubric. Participants' abilities were assessed on a continuum ranging from (4) clear, consistent, and convincing evidence to (1) little or no evidence. The level of teacher performance expected for each research hypothesis was (3), proficient. Based on artifact assessment throughout the pilot and field studies, improvements were made to the T2I2 System Architecture to assure ease of use for researchers, developers, assessors, and teacher participants.

The project infrastructure provided an internal site which allowed for creating and packaging Professional Development Learning Objects, delivering and sharing documents and edited improvements, and evaluating teacher learning, all within a dedicated project website. Figure 1 depicts the T2I2 System Architecture. The project website gave writers, contributors, and participating teachers access to the site. All resources were cloud-based allowing for authoring, publishing, delivering assessment, community building and cyber coaching. Modifications to the cyber infrastructure streamlined the teacher interface and increased the frequency of cyber coaching, with little changes to the base System Architecture.

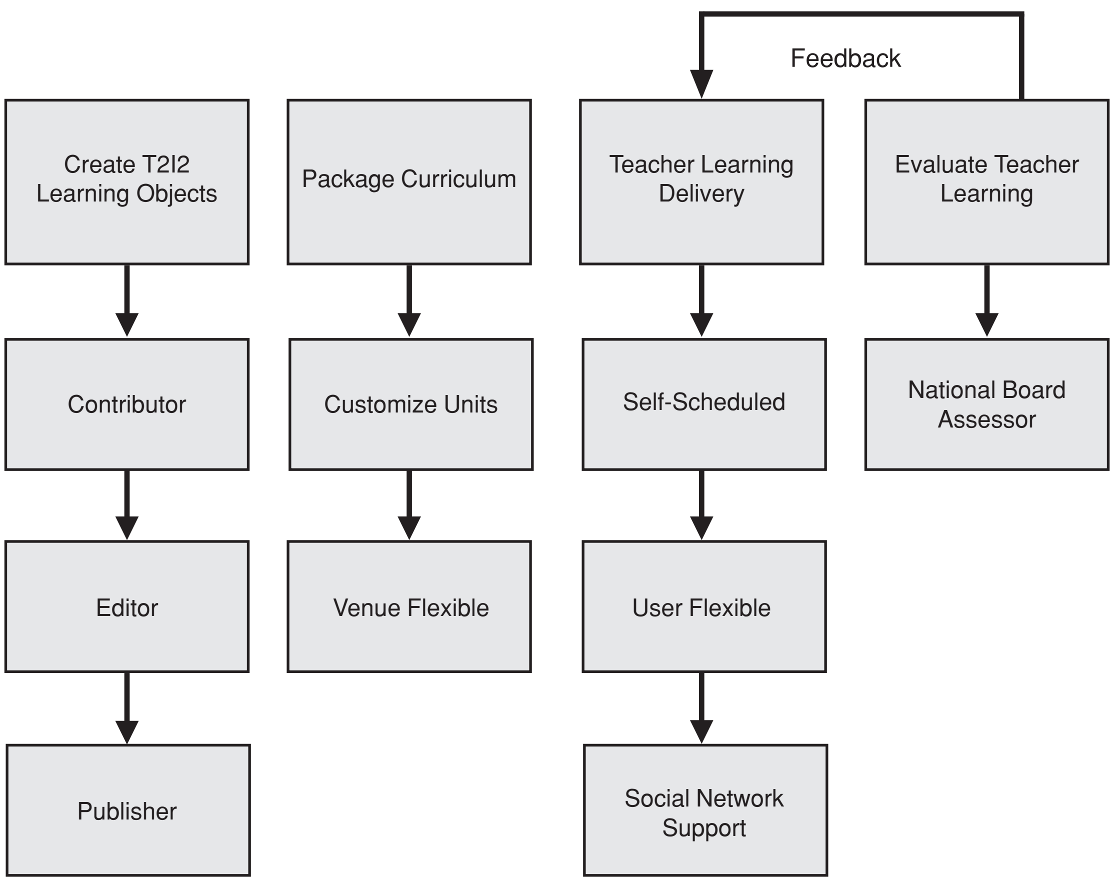

Figure 1. T2I2 System Architecture

DATA AND ANALYSIS OF FINDINGS

All data was analyzed following the same quantitative research methods employed for the pilot study data. Teachers' artifacts from both field study groups were reviewed and assessed. The non-parametric Wilcoxon-signed-ranks Test, a test of hypothetical value, was used to analyze the participants' assessment scores. This analysis provided evidence to address the five research hypotheses that targeted the teachers' abilities to contribute to learning communities; monitor, manage, and adjust learning environments; and increase self-assessment.

As stated previously, an assessment score of 3 indicated a teacher's abilities as "proficient," according to the NBPTS scoring rubric. With this in mind, a median ≥ 3 was the specified parameter for this field study. Table 3 displays the results of the Wilcoxon-signed-rank Test of hypothesis for the five directional research hypotheses. Data from the two combined years reflects the participation of 19 educators.

Analysis of the data compared the Wilcoxon-signed-ranks Test to the related critical value associated with the sample size of the data generated by the participants. The sample size was less than 50, indicating no need for normal approximation with the continuity correction. The reported *p*-value is exact with a critical alpha value set at 0.05 for this study (Noymer, 2008). As noted in Table 3, the number of instances varied based upon each outcome variable's number of constructs.

The research hypotheses were all directional identified by the notation $H_1 : \Theta > 3$. Based upon the analysis of each set of data, the researchers failed to reject each positive directional hypothesis. The data suggests that the field study teachers' participation in the T2I2 professional learning experiences supported their ability to contribute to the learning community; manage, monitor, and adjust the learning environment; and increase their self-assessment.

The researchers were also interested in gathering information about the T2I2 web-based learning environment through the collection and analysis of teachers' user and access data. Comparisons of the pilot and field study teacher user data, which includes quiz scores and teacher trials, can be found in Table 4. Field study participants' mean quiz scores were somewhat lower than those of the pilot group and their average number of attempts for the quizzes were also lower. This suggests that the teachers were using the quizzes as quick self-check formative assessment tools, as was intended by the researchers.

Teacher access data considered the average time teachers spent on each unit. A comparison of both the pilot and field study groups' results can be seen in Table 5. As the user interface was enhanced based upon pilot teacher feedback, teachers devoted more time to each unit. The data suggests that the platform supported and encouraged participants' authentic use of the provided instructional materials.

Implications

This summative assessment reinforced the pilot study findings that the T2I2 professional development supported participating educators' abilities to manage, monitor, and adjust their learning environments; increased their ability for self-assessment, and increased their contributions to the learning community. Although the schema of the study targeted technology and engineering educators, the topics of the T2I2 Learning Object lend themselves to each of the STEM disciplines. Notable commonalities among the STEM practices support the development of interdisciplinary T2I2 teacher learning materials. To move the project in this direction, a parallel portfolio of science T2I2 Learning Objects are currently under development. The science T2I2 learning experiences are framed by the *Next Generation Science Standards* (NGSS) and will support educators to develop design-based teaching practices. The prototype science Learning Objects will be delivered utilizing the T2I2 web-based architecture and utilized with both pre-service and in-service science educators.

The asynchronous, easily accessible, web-based resources provided flexible and job-embedded professional development for the participating in-service teachers. The design of the T2I2 resources allowed for self-paced learning utilizing a platform that promoted networking and collaboration. Successes within this project should inform future professional development opportunities and leverage lessons learned from both curricular and infrastructure design.

TABLE 3: Wilcoxon-signed-rank test of hypotheses

Research Hypothesis	*n* = scoring instances possible	*n* for test	Median Est.	Wilcoxon Stat.	p-value	Method
RH1	19	13	3	30	0.4122	Normal Approximation
RH2	19	13	3	56	0.2141	Normal Approximation
RH3	19	19	3	15	0.9254	Normal Approximation
RH4	19	13	3	3	0.932	Normal Approximation
RH5	19	19	3	12	0.8364	Normal Approximation

TABLE 4: Pilot and field study teacher user data

	Mean Quiz Scores		Average Number of Attempts for the Quiz	
Units	Pilot Group	Field Study Group	Pilot Group	Field Study Group
Assessment of Student Learning	94.50	88.21	4.50	2.25
Demonstration Lesson	100.00	93.85	3.83	1.75
Fostering Teamwork	98.46	92.31	3.15	1.72
Documented Accomplishments	97.78	79	3.22	5

TABLE 5: Pilot and field study teacher access data

	Average Time Spent on Unit (minutes)	
Units	Pilot Group	Field Study Group
Assessment of Student Learning	3.38	24.19
Demonstration Lesson	2.84	20.67
Fostering Teamwork	5.99	16.72
Documented Accomplishments	2.94	17

CONCLUSIONS

The pilot and field study data supports continued use of the T2I2 flexible professional development resources and infrastructure. This platform could be a tool to deliver online asynchronous professional learning to all STEM educators. The Learning Objects, while initially developed to address the professional development needs of technology and engineering educators, frame cross-STEM discipline best practices. The commonalities among STEM disciplines and similar professional development logically leads to developing interdisciplinary T2I2 Learning Objects that model the integration of STEM content and practice.

The T2I2 system architecture and cyber infrastructure provides a tested platform and tool for online asynchronous professional learning experiences. This system has proven to be flexible and easily accessible for content developers, researchers, course facilitators, and participants. The platform and shared learning experiences developed a powerful community of technology and engineering educators. This community of learners would be strengthened by the inclusion of science and mathematics educators to truly develop an integrative STEM community of learners.

The authors recommend developing and implementing pre-assessment tools to set a baseline for the T2I2 learning prior to teacher participation within the units. Identifying teachers' initial levels of understanding could inform modifications and the development of future Learning Objects.

This summative assessment confirms the value of the T2I2 learning materials, resources and delivery system. Teachers' professional development requires teacher agency, giving teachers more control over their learning (Mehta, 2016). Unfortunately, unlike the T2I2 resources, the bulk of online professional development opportunities are activity and content focused, not classroom-practice based. The unique professional development needs to prepare STEM educators to build and maintain effective integrated learning environments can be addressed and supported by the T2I2 resources and platform.

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Jeremy V. Ernst *is an Associate Professor of Integrative STEM Education in the School of Education at Virginia Polytechnic Institute and State University, Blacksburg. He is a member of the Gamma Tau Chapter of Epsilon PI Tau.*

Aaron C. Clark *is a Professor and Director of Graduate Programs for the Department of STEM Education within the College of Education at North Carolina State University. He is a member of the Alpha Pi Chapter of Epsilon Pi Tau.*

Sharon W. Bowers *is a Senior STEM Education Specialist for the Center for Integrative STEM Education (CISE) at the National Institute of Aerospace (NIA).*

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Professional Advisers in Engineering and Technology Undergraduate Programs: Opportunities and Challenges

By Gretchen A. Mosher

ABSTRACT

The basis of high quality academic advising is a strong relationship between the student and the adviser. Historically, these relationships have been cultivated between faculty advisers and students. Increasingly, the "faculty-only" model is declining, as institutions have chosen to hire non-faculty staff to serve the role of academic advisers. These "professional advisers" focus solely on advising, with limited research, teaching, and governance duties. This article summarizes the research on the use of professional advisers as compared with faculty advisers, and outlines challenges inherent to the professional adviser model in an engineering and technology department at a research-intensive land grant institution. Information on the use of professional advisers in an engineering and technology department may be useful to other engineering and technology-oriented departments, specifically those managing large enrollment increases. Factors considered in measuring advising effectiveness for professional and faculty advisers will also be discussed. As administrators in engineering and technology departments
add to the list of tasks required for faculty, the use of professional advisers shifts the faculty mentoring focus toward disciplinary and career pursuits, roles faculty have indicated they are comfortable assuming.

Keywords: academic advising, administration, undergraduates

Effective academic advising has been associated with several positive characteristics in undergraduate students, including cognitive and social development and persistence (Pascarella & Terenzini, 2005). High quality advising has also been shown to play a critical role in student academic, career, and personal development (Beggs, Bantham, & Taylor, 2008). While post-secondary institutions profess a commitment to advising, the quality of the advising, as perceived by students, varies in quality and effectiveness (Hossler, Ziskin, & Gross, 2009).

Facilitating effective advising is challenging. Hale, Graham, and Johnson's (2009) survey of over 225,000 undergraduates at over 425 U.S. post-secondary institutions found academic advising was second only to the quality of instruction as the most important component of the college experience. Cox and Orehovec (2007) added that when students are connected and engaged with their advisers, they are more likely to feel valued as individuals, enhancing their likelihood of academic success. A high level of engagement is especially important at high enrollment, research-intensive institutions. Even though a strong connection between student and adviser has implications for multiple positive student outcomes (Vianden & Barlow, 2015), students often report dissatisfaction with the academic advising they receive (Allen & Smith, 2008: Keup & Stolzenberg, 2004).

Historically, faculty advisers have borne the majority of the advising load. Habley (2003) noted that faculty advising was influenced by an increase in the diversity of students served by post-secondary institutions, the evolution of the curriculum to include wider areas of study, and increased expectations for faculty performance. Faculty continue in an advising role at many institutions, but the question of whether this is the best model to meet student advising needs is raised by Allen and Smith (2008) and others (White, 2013). Baker and Griffin (2010) noted that traditionally, faculty advisers were expected to assist students in with the needed navigation of academic rules and policies, yet others have reported that effective advising is much more than knowledge of major and degree requirements (Allen & Smith, 2008).

Accordingly, much has been written on the components of effective academic advising (Allen & Smith, 2008; White, 2013; White, 2015). The research of Janine M. Allen and Cathleen L. Smith (Allen & Smith, 2008; Smith & Allen, 2006) summarizes five domains drawn from over 30 years of literature on the subject, including integration, referral, information, individuation, and shared responsibility. Allen and Smith also reported that although faculty found all five domains important, they did not feel they were responsible for cultivating all five with their students. Specifically, Allen and Smith (2008) discovered that student and faculty perceptions of effectiveness aligned fairly closely on the domains of information and individuation, and were further apart in the domains of integration and referral.

Sheldon, Garton, Orr, and Smith (2015) found three factors that predicted student satisfaction with their adviser's performance: knowledge, availability, and autonomy supportiveness. Of the three, autonomy support was the strongest predictor for student satisfaction as well as student cumulative GPA and student time spent with advisers. Autonomy support was defined by Sheldon et al. (2015) as the ability to communicate and counsel without forcing the will of the "authority" on the "subordinate." In this case, the authority is the adviser and the subordinate is the student. The construct of autonomy support has been studied across a variety of domains, according to Sheldon et al. (2015), including counseling, medicine, parenting, management, and others.

Baker and Griffin (2010) added that high-quality advisers ensure that students have the information they need to make good decisions. Baker and Griffin (2010) also noted that the mentorship of a student often falls outside sharing academic information. Smith and Allen (2006) and Allen and Smith (2008) reported that not only are many faculty members uncomfortable advising outside of the academic realm, they do not believe it is their responsibility. For this reason, administrators have considered other options.

Responsive and high-quality advising is an important component in retaining STEM students (Meyer & Marx, 2014). STEM fields have struggled to recruit and retain students, even though data have shown little academic difference in those who persist and those who do not (Lichtenstein, McCormick, Sheppard, & Puma, 2010; Seymour & Hewitt, 1997). The so-called leaky pipeline to STEM professions is well known by researchers; however, the reasons students leave are less universal. Effective academic advising is hypothesized by many researchers to play a significant role in student persistence and retention (Geisinger & Raman, 2013; Pascarella & Terenzini, 2005;Vianden & Barlow, 2015). Yet, the academic advising literature has not examined the role of academic advisers specifically, especially in the fields of technology and engineering.

As administrators seek to optimize the use of faculty's time with fewer financial resources, professional advisers become one option to meet the advising needs of undergraduate students while improving the quality of advising (Sheldon et al., 2015). Engineering and technology departments, like most STEM fields, teach a hands-on and practical curriculum, which takes additional time and preparation (Asunda, Kim, & Westberry, 2015). The teaching approach leaves faculty with even less time to take on advising tasks. Professional advising personnel can address some of these challenges. These advisers are generally hired to meet a broader set of student needs, including academic and curricular needs, career exploration, transfer articulation agreements, development activities, and recruitment (Self, 2011). When professional advisers address these student needs, it leaves faculty with more time to pursue research, service, and instructional activities

Professional advisers are not disciplinary experts; rather, their expertise is in student development and university policies and procedures (Self, 2011). Professional advisers have the academic preparation and availability to provide effective service to students in the five domains advocated by Smith and Allen (2006) as well as the three factors described by Sheldon et al. (2015). Additionally, professional advisers are qualified to manage complex and time-consuming mentoring issues, including events related to student resilience and academic fit. They also generally have a broad knowledge base of campus resources for efficient referral of students for mental health, financial, and other challenging obstacles that can delay graduation. The use of professional advisers does not remove the faculty from a mentorship role, but it shifts the focus of the relationship to a disciplinary mentorship and "developer" as described by Baker and Griffin (2010).

BACKGROUND

Retention of STEM students is a well-documented challenge, but the reasons for this vary. Research on faculty perceptions of student persistence in

STEM studies shows study habits, commitment to educational goals, and family support as the primary influencing factors (Ortiz & Sriraman, 2015), but other researchers report that the main reasons students depart STEM fields are non-academic (Geisinger & Raman, 2013; Marra, Rodgers, Shen, & Bogue, 2012).

A primary focus of the advising team in the author's department has been to increase recruitment and retention of students who are good fit for the curricular programs in the department. The author's University has seen dramatic enrollment increases in the last 5 years and the use of professional academic advisers has limited the negative impact these higher enrollments have on faculty time. Yet, the increased enrollment has not been without challenges.

Little research has been completed on the use of professional advisers in engineering and technology fields or on the evaluation of professional academic advisers, especially in high enrollment departments within a research-intensive environment. A second area unexplored by previous literature is best practices for advising students who transfer out of the "E" of STEM fields into other disciplinary areas, specifically into the "T" component of STEM. Past analyses of these students suggest they may have advising needs that differ from students entering directly from high school.

As engineering and technology programs nationwide struggle to recruit and retain graduate students and prepare future faculty, appropriate undergraduate preparation and early professional engagement in the field is critical (Martin, Ritz, & Kosloski, 2014). Academic advising is hypothesized to play a key role in promoting student success, which is not only important in the short-term to ensure an adequate supply of engineering and technology professionals, but is also important for the long-term sustainability of the field of technology and the development of its future faculty. Therefore, a better understanding of best practices for working with technology students is needed.

The goal of this manuscript is to share the approach and philosophy for using professional advisers in an engineering and technology program at a research-intensive university in the Midwest United States. A specific focus on how students who transfer into the department from other engineering departments are welcomed into the department makes up the first portion of the article. The second portion proposes an evaluation plan to measure the effectiveness of the advising unit. Research opportunities to explore advising with internal transfer students in STEM will follow in the conclusion of this article.

Characterizing Students and their Needs

Undergraduate enrollment at the author's University has seen a large increase of students during the past 5 years. A major challenge of the increased enrollment has been handling students who transfer from engineering "E" fields into technology "T" fields. These students are termed *internal transfers* -- defined as students who transferred into a departmental major from another major within the university rather than as a transfer student from another institution or one entering directly from either high school or the military.

Institutional data from the author's department show that during 2015-2016, approximately 80 percent of internal transfers into the field of engineering technology – including the majors of agricultural systems technology (AST) and industrial technology (ITEC) -- transferred from an engineering discipline. The majority of internal transfers are male students.

Internal transfer students have wide variations in background, academic success, and perceptions of both the University and higher education. For this reason, a primary goal of the faculty and advisers is to acclimate and integrate the internal transfers into the department and provide them with guidance on its culture, expectations, and values regarding student development. A secondary goal is to (re)build confidence and efficacy in students whose plans in their initial chosen major did not turn out as expected. The academic advising team is an important welcoming link to students entering the department from elsewhere in the University. To address academic and social challenges of internal transfer students, faculty and advisers focus on a quick integration into the department through a variety of course experiences, administrative systems, and social activities.

Student feedback on the quality of academic advising in their "new" department has been very positive. Many of these students have not had positive academic experiences previously. When they transfer into the department, the academic adviser is the first person they interact with. For many of them, it offers the first positive step toward their successful completion of a degree. From an anecdotal perspective, the value of a positive interaction with an academic is critical. However, little research has quantitatively examined the value of these initial interactions.

Facilitating Successful Transfers

The goal of both faculty and advisers is to facilitate a successful transfer experience for each student. To enable this, several programs are implemented. Initially, a greater level of guidance is in place, with greater levels of independence and self-sufficiency expected from students as they near graduation. The first two years in the major are characterized by coursework to familiarize students with departmental labs and foundational knowledge in mathematics, chemistry, and physics.

The professional adviser team plans, administers, and leads the two foundation courses in engineering and technology. As part of the foundational courses, students tour two or more industry sites to expose them to opportunities in their new field of study. Alumni and faculty panels provide information for students on advanced coursework and internship experiences.

Following the principles for effective undergraduate education advocated by Chickering and Gamson (1999), the advising team works to introduce new students in the department to faculty to enhance faculty/student contact. Faculty members are the students' first link with the discipline so the advising team plans and oversees several formal and informal contact opportunities between students and faculty during the academic year.

Formal opportunities include faculty panels where students ask questions about coursework, professional opportunities, and career specifics of teaching faculty and tours of laboratories and teaching areas. Tours of labs and programs in power machinery, fluid power, electricity, bio-processing, and occupational safety are presented. These give students a good understanding of the expectations of the department while encouraging student and faculty contact, both good principles identified by Chickering and Gamson (1999). Informal opportunities include an ice cream social, held in the late afternoon in the fall semester and a breakfast break with coffee and doughnuts, held in the spring semester. Both events run

TABLE 1: Characteristics of departmental enrollment trends and gender balance

Major	Spring 2016 Enrollment	Internal transfers IN 2015-2016	Internal transfers 2015-2016 OUT	Gender Proportion
Agricultural Engineering	192	31	48	Males 83.3% Females 16.7%
Agricultural Systems Technology	206	23	12	Males 94.7% Females 5.3%
Biological Systems Engineering	97	21	2	Males 46.4% Females 53.6%
Industrial Technology	269	93	11	Males 95.2% Females 4.8%

approximately 90 minutes and are open to all undergraduates in the department. Faculty and staff are invited to meet students, introduce themselves, and engage in brief conversations. These events encourage student-faculty contact as outlined by Chickering and Gamson (1999) in their seven principles of good practice in undergraduate education.

These two activities – social events and foundational courses – coordinate with the department's learning community programs. Learning communities are created to enhance the student undergraduate experience through elements such as teamwork, trust, and diversity to encourage participation and sharing of leadership tasks (Ancar, Freeman, & Field, 2007). The current departmental learning communities are course-based, meaning that engineering and technology students take one or more courses together, along with other opportunities to engage with peers, student mentors, and faculty. Another important component is the use of "peer mentors" – juniors and seniors in the major that are assigned to mentor small groups (12-15 students in each group) of new students.

The engineering and technology learning communities in the department have been in existence for nearly 20 years (Freeman, Field, & Dyrenfurth, 2001) and during that time, multiple changes in implementation and administration have been made. However, the original focus on increasing the interaction of students with their peers and with the faculty remains (Freeman, et al., 2001). This focus aligns well with the goals of the advising team and with the seven principles of good undergraduate education (Chickering & Gamson, 1999). Chickering and Gamson's (1999) seven principles of good undergraduate education have been in place for nearly 30 years, yet remain relevant for contemporary administrators and faculty.

The last informal opportunity faculty and student have to interact is at the graduation reception, held on a weeknight at the end of the fall and spring semesters. Graduating seniors are invited to a meal where they are invited to share their future plans and favorite memories of their time in the department. Faculty members are also given the opportunity to share final words of advice with students and wish them well on future endeavors. The event is a business casual, with a light meal served. The evening ends with photos taken of the graduating students, one photo that is serious and one that is less serious. The photos are then posted on the department's website and broadcasted through the department's Twitter and Facebook pages. The semester ends on a high note and lets students know that faculty in the department are invested in their success. All of these events are coordinated by the academic advising team and administrative staff. The events have been very successful in making students feel valued and connected at the beginning, middle, and end of their affiliation with the department.

A successful internal transfer experience is only partially related to the social aspects of a department. Another important factor is the speed with which a student transferring from another department can complete the required coursework and graduate. Internal transfers come into the department with a variety of coursework experiences on their record. Some have only one semester in the higher education, whereas others bring 2 years of community college records plus one or two semesters of 4-year transcripts. The academic status of students also varies widely. Some students transfer into the department with GPAs of 3.5 and above, but others have one or more academic dismissals in their history before they find a degree program that fits their background and skills.

It is in these cases that the quality of advising can play a large role in the success and efficacy of the student. Advisers play a large role in first introducing the department and welcoming students in, but in the second case, and perhaps more important one, advisers work with the student to identify a successful path forward in the curriculum.

One significant way advising staff can facilitate the student's curricular path forward is through enrollment management. Due to high enrollments in the engineering and technology programs, some form of prioritizing is necessary to ensure students are taking courses in the most efficient manner. Using criteria such as graduation date, number of credits, and existing schedule, advising staff manage the complex task of getting the right students in the right set of courses so that they can graduate on time. The key performance indicator for this task is to have no student graduation delayed because of simple logistic issues related to getting students into needed courses. Thus far, the department has met this goal.

Undergraduate academic advising plays a major role in the academic, social, and emotional development of undergraduate students, as well as in the successful retention of students (Hossler, Ziskin, & Gross, 2009). In the author's department, students bring additional advising challenges, as addressed previously. Programming and academic advising practices follow the seven principles of high-quality undergraduate education, but the faculty have also tried to be creative in addressing challenges of high enrollment and students with unique advising needs. Because of the resources invested in effective advising at the department level, an evaluation plan for the undergraduate advising program is critical.

Approaches to Evaluating Advising

Evaluation of academic advisers is not simply a review of job performance. Professional advisers oversee many aspects of undergraduate degree programs and interact with students, departmental faculty and staff, and student services staff across the University and beyond. Indeed, as reported by Beggs, Bantham, and Taylor (2008), academic advising plays a major role in student life choices such as academic major or career. Young-Jones, Burt, Dixon, and Hawthorne (2013) presented six advising factors that were significantly related to student success. These factors include: accountability, empowerment, student responsibility, student self-efficacy, student study skills, and perceived report. These factors build on the idea that advising is grounded in teaching and learning; but include other evaluative components, as noted by Campbell and Nutt (2008) and others. Campbell and Nutt (2008) also suggested the implementation of structures and programs that recognize and reward the value of high quality academic advising.

For this reason, the evaluation of undergraduate advisers is critical and includes feedback from students, faculty, and staff from within the department. The process used by the Author's department is based on factors identified by Young-Jones et al. (2013). Student feedback is gathered from students through an online survey. Students are generally given approximately 10 weekdays to complete the survey, and an automated email reminder is sent to each student regularly until he or she submits the survey. Departmental faculty and staff may also provide feedback to the faculty supervisor of the advisors, following an existing departmental procedure for faculty to evaluate the job performance of professional staff they supervise. Finally, the supervisor holds a job performance meeting with each academic adviser. A summary of the meeting discussion and recommendations should be forwarded to the adviser for review before the documentation is submitted to departmental and university human resources.

The following 7 questions are examples of questions students could answer using a scaled survey instrument.

- My adviser is well informed about rules, procedures, and course selection. If the answer isn't known, my adviser helps direct my question to appropriate resources.
- My adviser is available through office hours, telephone, email, or office appointments, if necessary.
- My adviser keeps appointments when made. She/he follows through with efforts to determine answers to questions.
- My adviser encourages me to contact her/him. She/he expresses interest in me and shows concern for my problems and my progress in the program.
- My adviser offers suggestions and evaluations. She/he informs me about university, community, and professional resources. She/he helps me make contacts or appointments when necessary.
- My adviser treats me in a professional manner. She/he creates a supportive environment and discusses decision-making strategies. She/he gives me her full attention during my visit(s).
- My adviser provides adequate guidance relating to my career goals.

Students are also questioned on their level of satisfaction with their adviser's overall effectiveness using a rating scale.

Responses to open-ended questions are another important part of continuous improvement with advising personnel. To facilitate this, students may also answer open-ended questions, such as the following four that are listed.

1. My adviser has helped me most by …
2. What are the strengths of your adviser?
3. In what areas could your adviser improve?
4. Please provide any additional comments about your adviser or the department's advising service in general.

Advising staff is an important part of the recruitment, retention, and academic team. Professional advisers provide substantial benefits to students in different ways than do faculty advisors. Advising professionals do not replace faculty as disciplinary mentors, but their expertise in student development, curricular policy, and working with high-risk students has proven valuable in a high enrollment engineering and technology department. When professional advisers manage the curricular and developmental components of advising, it frees the faculty to focus on what they do best: serve as disciplinary mentors for students (Baker & Griffin, 2010). The department envisions academic advising as a continuous team effort, and the use of professional advisers facilitate this approach.

Future Research Directions

There is a lot that researchers do not know about students who transfer from the "E" to the "T" of STEM, particularly related to success factors and effective predictors of their successful integration into the new field. Differences in the learning styles of engineering and technology students are not well explored in the research literature (Asunda, et al., 2015). Also, specific information on how faculty and advising staff build or re-build the efficacy of students who have had previous academic setbacks in engineering have had little emphasis in published literature.

An emerging field of research has explored best practices for advising STEM students (Haag, Hubele, Garcia, & McBeath, 2007; Meyer & Marx, 2014). Yet, little research exists on specific practices to best serve students transferring from one STEM field to another. Additionally, methods of establishing or re-establishing efficacy for students in the "new" discipline have not received great attention in published literature. Internal data from the author's academic department suggest that technology students differ from engineering students in how they learn, how they approach problem solving and critical thinking, and how they establish their disciplinary expertise. Furthermore, factors that influence the success of students who transfer into technology from engineering have not been examined in the literature. One factor hypothesized to influence a successful transfer is *effective academic advising*. Addressing these factors through empirical research is critical for the discipline and for the future of engineering and technology academic programs at both the undergraduate and graduate level.

Dr. Gretchen A. Mosher *is an Assistant Professor in Agricultural and Biosystems Engineering at Iowa State University, Ames. She is a member of the Alpha Xi Chapter of Epsilon Pi Tau.*

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Case Study on the Two Individual Paradigms of Education in a Manufacturing Quality Course

By
Rustin Webster and Matthew Turner

ABSTRACT:

This article provides a review of two paradigms of education and the application of each in a manufacturing quality control course for engineering technology (ET) students. The most common paradigm of education used in quality-focused courses is teaching-centered. This traditional method has contributed to students' perception of quality (e.g., quality control, statistical process control, total quality management), as a dry subject to learn compared to other core and/or elective courses in their plans of study. This case study describes the creation and implementation of a manufacturing quality control curriculum that is learning-centered. Based on student feedback, this approach increased ET students' self-reported satisfaction of the course, lab, and instructor, as compared to a teaching-centered course. Additionally, the students' engagement and dynamic involvement in the learning activities increased, due in part to project-based learning. In order to enhance further adoption of student-centered instructional techniques in quality-focused courses, the authors have shared all project-based learning resources.

Keywords: Manufacturing Quality Control, Paradigms of Education, Active Learning, Project-Based Learning, Engineering Technology

INTRODUCTION

The use of lectures and problem sets as the default model of engineering and technology education is increasingly giving way to evidence-based instructional methods, primarily active learning. Instructors use active learning to engage students beyond passively sitting and listening to a lecture through activities such as peer teaching, team-based problem-based learning, project-based learning, or discussion-based learning. In general, active instructional techniques enhance learning compared to traditional lecture for most students (Freeman et al., 2014). However, Streveler and Menekse (2017) have recently argued that although active learning has been sufficiently proven, it is not a "blanket remedy for all instructional inadequacies" (p. 189) and significant work remains to determine the relationship between the different active learning strategies and their effect in and on different situations, disciplines, learning objectives, and students. This work responds to that call by presenting a case study of the application of two paradigms of education (i.e., teaching-centered and learning-centered) in a manufacturing quality control course for engineering technology (ET) students.

Definition

Although there are no universally accepted definitions for many of the terms used in this paper, the following list is representative of commonly accepted definitions as utilized in the published literature relating to higher education. The authors have provided them to enhance clarity and consistency among readers.

- Paradigm. A frame of reference that determines how we perceive, interpret, and make sense out of how we educate students (Johnson, Johnson, & Smith, 2006, McManus, 2001).
- Teaching-centered paradigm. The traditional paradigm of higher education with discussions generally centering on the use of passive learning instructional methods (e.g., lecturing), and a classroom environment where the instructor teaches the subject to the student and expects them to learn it (i.e., instructor is central) (McManus, 2001). *Has become engrained in higher education through widespread adoption.*
- Learning-centered paradigm. Discussions generally center on the use of active learning instructional methods (e.g., project-based learning), and a classroom environment where the instructor helps the students learn the subject (i.e., instructor and student are partners) (McManus, 2001). *Traditional instructional activities, such as homework, exams, quizzes, and lectures may also occur when the instructor is not acting as a coach or mentor.*

- Passive Learning. The use of teacher-centered methods favoring lectures presented by an instructor to an audience of students. (Menekse, Stump, Krause, & Chi, 2013). *Teaching is the emphasis.*

- Active Learning. Instructional methods that require students to do meaningful learning by participating in activities (Bonwell & Eison, 1991, Prince, 2004). *Learning is the emphasis and the core is student engagement and dynamic involvement in the learning activity.*

- Project-Based Learning (PBL). A form of active learning in which learning activities are context specific, students participate in the learning process, and goals are achieved through social interaction and the sharing of knowledge (Kokotsaki, Menzies, & Wiggins, 2016). Distinction from active learning may be made by the extended length of time students work to investigate and respond to a complex question, problem, or challenge (Donnelly & Fitzmaurice, 2005) and that the work produces a realistic product or presentation (Jones, 1997).

Literature Review

Educational fields, such as E , that contain well-defined content and skills to be learned are often teacher-centered, with an emphasis on the transmission of information. This perspective, often called the Engineering Conception, values teacher expertise, efficient content coverage, productive time management, and the development of instructional materials (Pratt, 1992). The act of teaching is therefore often a matter of presenting one’s knowledge in a clear and accurate format, often utilizing educational media such as slide-based presentations (Kember & Gow, 1994). Although common in higher education, major deficiencies in the instructional techniques based in the Engineering Conception have been identified, including high drop-out rates due to poor-quality learning environments (Seymour & Hewitt, 2000), and an overall decline in the competitiveness of the American Science, Engineering and Math (SEM) workforce (National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007). These, and other, pressures have led to widespread support for changes to STEM education methods. For example, George (1996) recommended that better educational outcomes could be achieve via a shift in the paradigm of STEM education toward environments of engagement, using direct experience with real methods and processes to excite students to explore and discover the areas of science, technology, engineering and math.

In contrast to the Engineering Conception, “learning-centered” approaches are methods that place an emphasis on the relationship between the teacher and the learner, with the instructional process focused on the cognitive development and personal autonomy of students (Pratt, 1992). This learning facilitation perspective is often characterized by a focus on high-level aims such as problem-solving skills, critical thinking, and independent learning and a view that teaching is a facilitating, interactive, procedure of motivating students and creating environments where students really want to learn (Kember & Gow, 1994). Learning-centered teaching methods are typically characterized using in-class activities and include active learning, cooperative learning, and inductive teaching and learning (Prince & Felder, 2006). A wide variety of studies have found support for such methods, particularly active learning. For example, integration of challenge questions, physicist-like reasoning, and problem solving during class time were shown to increase student attendance, engagement, and learning in a large-enrollment physics class (Deslauriers, Schelew, & Wieman, 2011). A similar intervention in a chemical engineering course found effects related to both improved grade-point average and drop-out rates (Bullard, Felder, & Raubenheimer, 2008). Such findings are typically consistent across STEM education literature, and support increased engagement and content retention, as well as improved student attitudes and study habits (Prince, 2004).

Like the broader category of active learning, a breadth of research supports the use of PBL in educational settings. Typically, these learning activities must meet five requirements: adds active participation by students (Cocco, 2006, Jones, 1997, Thomas, 2000), is realistic and context- specific content (Blumenfeld et al., 1991, Cocco, 2006, Thomas, 2000), produces a product or presentation (Blumenfeld et al., 1991, Helle, Tynjälä, & Olkinuora, 2006, Jones, 1997), is collaborative or team-based (Blumenfeld et al., 1991, Cocco, 2006, Helle et al., 2006), and lasts for extended periods of time (Jones, 1997). Instruction that uses methods meeting these criteria has been shown to improve student learning in a variety of ways. Primarily, PBL has been shown to increase student engagement and interest because of the cognitive challenges associated with the project (Wurdinger, Haar, Hugg, & Bezon, 2007) and the real-world problem solving (Lou, Shih, Ray Diez, & Tseng, 2011, Verma & Dickerson, 2011). In addition, it has been shown to promote the learning of conceptual knowledge (Barak & Asad, 2012), critical thinking skills (Shepard, 1998, Tretten & Zacharious, 1997), and educational resource utilization (Barron et al., 1998).

Additionally, a variety of design factors have been identified that influence P implementations. PBL must be accompanied by didactic instruction (Grant & Branch, 2005), and it is best utilized in a two-phase approach: phase 1 is to introduce the knowledge and technology concepts, and phase 2 is to implement the knowledge via independent design and production (Drain, 2010). Scaffolding techniques should be used to guide instruction by structuring tasks in ways the enable learners to focus primarily on the aspects of the task related to learning goals (Hmelo-Silver, Duncan, & Chinn, 2007). Finally, effective group dynamics must be encouraged, creating and environment of positive interdependence, individual accountability, and equal participation, such that both high and low achieving students can benefit from group processes (Cheng, Lam, & Chan, 2008).

Despite the evidence supporting PBL and the relative prevalence of quality-focused engineering and engineering technology courses (Callahan & Strong, 2004), little research has been done on the implementation of PBL in quality classrooms. There have been no studies comparing students' learning outcomes between teaching-centered and learning-centered approaches to the same course. The following paragraphs summarize the existing literature.

Researchers have reported on the use of a variety of active learning pedagogies (e.g. PBL, team-based learning, and problem-based learning) for quality education. One of the most common is the use of catapults, or commonly called statapults, to study statistics and design of experiments. Sun and Gao (2015), designed an experiment to simulate the manufacturing improvement process. The students viewed the action of shooting a projectile (i.e. tennis or golf ball) with a catapult as a production process with variation (i.e. shooting angle, location of tension springs, etc.) and the target as product specifications. After 100 shots, students analyzed the data by creating control charts and identifying assignable and unassignable causes of variation. The experiment continued with additional rounds of shooting but each time students used prior results to improve the process. Adams (2000), utilized a statapult in a similar manner for hands on projects in an Introduction to Statistical Quality Control course. In both instances, qualitative data collected from students and instructor observations were positive.

Wang (2004), created a role-playing game for a quality control class to help teach students the concepts of Total Quality Control (TQC). Various student teams manufactured maple leaf bookmarks and one team acted as a fictional custome . The instructor required students to role-play various positions (e.g. CEO, marketer, designer, engineer, and inspector) on each team, which demonstrated the dynamic relationships that can occur in competitive manufacturing environments. The researcher collected student attitudes on the game by a simple self-created survey. Based on the feedback and instructor observations the game approach to teaching TQC was effective in teaching abstract concepts and representing certain levels of real-world experiences.

THE CASE STUDY

MET 45100, Manufacturing Quality Control, is an elective typically offered in the Spring to ET students majoring in Mechanical Engineering Technology (MET), Mechatronic Engineering Technology (MHET), and Engineering Technology at Purdue Polytechnic New Albany. The majors are part of the School of Engineering Technology (SoET) at Purdue University. Students are encouraged to take the course in their junior or senior year and after passing STAT 30100, Statistics.

The purpose of the course is to engage students on past, present, and future issues pertaining to the management of quality in services and manufacturing, in international and domestic markets, as well as in the private and public sectors. Furthermore, the conceptual and analytical skills developed in this course should enable the student to provide leadership in managing for quality. The course objectives are as follows:

- Communicate on quality management theory, principles, and practices
- Recognize the need for continuous quality improvement
- Understand and communicate on various quality control philosophies and methodologies
- Quantify and control quality through statistical methods
- Employ several quality control tools for identifying quality problems and causes
- Analyze a company's quality culture and make recommendations for improvements

The following sections will review the past three offerings of MET 45100. The first was in the Spring of 2015 and the third and fourth were offered in the Fall of 2015 and Fall of 2016 respectively. Along with a change of instructor between the first and second, the educational paradigm for the course changed from teaching-centered to learning-centered.

Teaching-Centered Paradigm

Spring 2015, 12 MET students (11 seniors and 1 junior) enrolled in MET 45100 at the Purdue Polytechnic New Albany campus. The instructor of record was a senior continuing lecturer of eight years, who had previously taught the course five times. In course planning and preparation, he adopted the teaching-centered paradigm. Over the 15-week course, class time was approximately split 85 percent lecture and 15 percent lab. The course met twice a week and lasted two hours each meeting. Students were required to purchase a textbook (Evans & Lindsay, 2012), which was the main source of information for the instructor and the students. The instructor used a Learning Management System (LMS) (i.e. Blackboard) for course organization, file sharing, assignment submissions, grading, and testing.

The instructor's goal was to transfer information and for the students to accumulate knowledge. Course design included a combination of lectures, textbook readings, exams, and assignments (i.e. textbook chapter questions and lab exercises). The instructor used a weighted grading scale to assess students' performance (see Table 1).

Exams (20 percent each) and individual assignments (3.08 percent each) were equally weighted. The instructor allowed the students to

TABLE 1. Spring 2015 Course Assessments

Item	Frequency (count)	Total Points Possible	Overall Grade Weight (percent)	Points Possible	Team or Individual	Length (weeks)
Exams[1]	3	300	60		Individual	
Assignments:			40			
1. Chapter Questions[2]	9	700			Individual	
2. Lab Exercises:	4	310				
a. Gauge R&R				100	Team	1
b. Card Drop Shop				100	Individual	1
c. Personal Quality SPC				10	Individual	15[3]
d. PEX Fusion				100	Individual	2

Notes: [1]Unequal available points per individual exams; [2]Unequal available points per individual assignments; [3]Conducted outside of normal class time form each three-member team for the gauge R&R lab exercise. The instructor did not allow for peer reviews at the completion of the lab exercise, thus grade adjustments per teammembers did not occur. Only the personal quality lab required additional work time outside of normal class time. All exams were open book and open notes. See Table 2 for additional details on each lab exercise.

Learning-Centered Paradigm

Fall 2015, 11 MET students (11 seniors) enrolled in MET 45100 at the Purdue Polytechnic New Albany campus. The instructor of record was a visiting assistant professor in his first years. In course planning and preparation, he adopted the learning-centered paradigm. Over the 15-week course, class time was approximately split 15 percent lecture and 85 percent active learning. The course met twice a week and lasted two hours each meeting. No textbook was required for the course, however Evans and Lindsay (2012) was recommended. The instructor created all lectures and assignments. He used the same Learning Management System (LMS) (i.e. Blackboard) for course organization, file sharing, assignment submissions, grading, and testing.

Fall 2016, 8 MET students (8 seniors) enrolled in MET 45100. The instructor did not change; however, his title became assistant professor. The course design and curriculum remained unchanged from Fall 2015 offering.

The instructor's goal was to create a learning environment in which students could learn to lectures, guided/facilitated group discussions, restructure new information and prior knowledge into new knowledge about manufacturing quality control and to

TABLE 2. Lab Exercises Details

Lab Exercise	Overview	Topic(s)
Gauge R&R	Using provided measuring equipment (i.e. caliper and measuring stick), students measure the distance between two identical items on the provided handout sheet. Stu-dents record, analyze, and interpret the data using Excel.	1. Variation 2. Professional Competencies[4]
Card Drop Shop[1,2]	Using supplied materials (i.e. paper target, deck of play-ing cards, and paper clips), students drop individual cards above a target and measure resting distance to the target. Students repeat experiment while changing variables (e.g. drop method and card weight) and record, analyze (i.e. ANOVA), and interpret the data using Excel.	1. Design of Experiments (DOE) 2. Process Capability 3. Data Collection, Analysis, and Interpretation
Personal Quality SPC	Students collect data for an extended period on an item or process from their daily lives. Students record, analyze, and interpret the data with emphasize on using the seven QC tools.	1.Variability 2. Data Collection, Analysis, and Interpretation
PEX Fusion[3]	Students brainstorm factors that affect a PEX tube butt joint strength. After creating an experimental plan (i.e. screening design), students use the Taguchi method to optimize joint strength. Students record, analyze, and interpret the data using Minitab.	1. Design of Experiments (DOE) 2. Data Collection, Analysis, and Interpretation

Notes: [1]See Alloway (1994) for additional details; [2]See Arnold (2001) for revised/updated edition; [3]See Eckert (2001) for sample fusion method; [4]A combination of effective communications, problem solving, critical thinking, project management, teamwork, self-directed learning, cultural awareness, and innovation.

practice using it. Course design included a combination of mini/bridging, guest lectures, exams, assignments, field trips, and projects. The instructor used a weighted grading scale to assess students' performance (see Table 3).

The class took two field trips to local companies towards the end of the semester. The purpose of the field trips were to allow students to witness and discuss with company personnel, classroom covered quality topics and techniques(i.e. real-world application). The instructor also invited a local manufacturing engineering manager to deliver two guest lectures. The first included a mini/bridging lecture on 5S and lean manufacturing, followed by hands on activities (Sato, Trindade, & Boersema, 2011, SuperTeams, n.d.) to reinforce lecture material. The second was an informational presentation on the guest's recent international travels and involvement with international suppliers and contractors. The speaker emphasized worldwide manufacturing quality themes.

Exams (7.5 percent each), assignments (2.5 percent each), and individual projects (16.7 percent each) were equally weighted. The instructor randomly selected four (Fall '16) or five students (Fall '15) for each 5S team and two students for the Bozo Challenge and the Company Visit projects (i.e. different team members per project). At the completion of each project, students had the opportunity to submit a review of each team member. The instructor used the peer review input and self-observations to adjust individual student project grades as needed. All exams were open resource (e.g. books, internet, etc.) but students were restricted to individual test taking (i.e. no collaboration).

TABLE 3. Fall 2015/2016 Course Assessments

Item	Frequency (count)	Total Points Possible	Overall Grade Weight (percent)	Points Possible	Team or Individual	Length (weeks)
Participation and Attendance		10	5			
Exams[1]	3	340	22.5		Individual	
Assignments[2]	10	94	22.5		Individual	
Projects[3]:	3	39	50			
1. 5S				18	Team	4
2. Bozo Challenge				13	Team	2.5
3. Company Visit				8	Team	13[4]

Notes: [1]Unequal available points per individual exams; [2]Unequal available points per individual assignments; [3]Unequal available points per individual project; [4]Conducted outside of normal class time

See Table 4 for additional details on each project and Appendix for PBL resources (i.e. class project handouts).

OUTCOMES

Course Surveys

Students at the end of each semester anonymously took a University created course evaluation survey. Administration used the same survey and distribution mechanism for all three-course offerings presented in this paper. The survey contains demographic-based questions, University wide questions about course and instructor, course specific questions, and optional written comment sections. Based on the purpose of this paper, the authors have chosen to present the survey results for the university questions, a single course specific question, and a sample of written comments. On the two university questions students, self-reported on their satisfaction of the course and instructor by selecting a response on a five-point Likert scale (where 5 = extremely good, 4 = good, 3 = fair, 2 = poor, and 1 = very poor) that best reflected their perception (see Table 5). The course specific question also used a Likert scale (where 5 = strongly agree, 4 = agree, 3 = undecided, 2 = disagree, and 1 = strongly disagree) to survey student perception (see Table 5).

Additionally, students had the opportunity to leave written comments to two questions. The first question asked, “What is something/are some things that the instructor does well, e.g., something you hope that the instructor will continue to do in the class in the future?” The second question asked, “Make a suggestion(s) for improving the course (a criticism alone is not helpful; tell your instructor how you would fix any problem).” See Table 6 for comments that the authors believe relate to the purpose of this paper.

TABLE 4. Project Details

Project	Overview	Topic(s)
5S	Teams add value and eliminate waste in a manufacturing lab by using the 5S technique. Teams are responsible for designing and implementing a 5S solution to an instructor identified problem area. Students report on project outcomes.	1. 5S: Sort, Straighten, Shine, Standardize, Sustain 2. Workplace Safety 3. Professional Competencies[2]
Bozo Challenge[1]	Using supplied materials (i.e. Xpult kit and Bozo Bucket Bonanza Grand Prize Game), students shot a projectile at buckets located a specified distance apart. Students design an experiment to optimize project success. Students record, analyze, and interpret the data using Excel.	1.Design of Experiments (DOE) 2. Variation 3. Data Collection, Analysis, and Interpretation 4. Professional Competencies[2]
Company Visit	Students arrange a tour of a local company after receiving instructor approval. Students meet quality personnel and analyze internal quality control methods/techniques. Students identify and recommend quality improvements and report on project outcomes.	1. Quality Control 2. Professional Competencies[2]

Notes: [1]See Peloton Systems LLC (n.d.) and Webster (2017) for additional details; [2]A combination of effective communications, problem solving, critical thinking, project management, teamwork, self-directed learning, cultural awareness, and innovation.

TABLE 5. Course Evaluations

Questions	Mean (Std. Deviation) Spring 15 *n* = 11/12	Fall 15 *n* = 11/11	Fall 16 *n* = 8/8
University Questions:			
1. Overall, I would rate this course as	3.90 (.96)	4.80 (.45)	4.80 (.43)
2. Overall, I would rate this instructor as	4.10 (.79)	4.80 (.45)	4.90 (.33)
Course Specific Question:			
1. The content of the lab is a worthwhile part of this course	4.10 (.67)	4.80 (.99)	4.70 (.99)

Notes: n = number of respondents/possible number of respondents

TABLE 6. Students' Comments

Questions	Spring 15	Fall 15	Fall 16
Question 1:	• "Tries to add videos and other media to make class more interesting"	• "The labs were great!" • "… made the course very interesting and engaging. Not a traditional environ-ment where he talked and we listened, but engaged us in conversation." • "He made what would normally be a dull class pretty interesting by having several active projects and taking field trips."	• "I really enjoyed the quality tours … Projects were also very fair and relevant to the course topic." • "Makes the class enjoyable by having interactive, group discussions and group pro-jects. This format also kept a rather dry subject to be fun to learn"
Question 2:	• "The class needs more labs …" • "The material of this course, yet useful, is also very dull. There needs to be more in class examples, group work, or labs to break up the lectures. This is nothing against the instructor, the material is just dull" • "More activities would make the topics a bit more interesting" • "Connecting material to student's workplace, such as a project or report"		• "The ping pong bozo thing was not what I'd consider a worthwhile project due to the disconnect between the concept and execution of that concept" • "Improve on having more projects …"

Project Examples

A goal of this paper is to share the PBL resources (see Appendix). To inspire future adoption by others, the authors have shared a sample of students' finished projects using the supplied handouts (see Figures 1-6 and table 7). Reference Webster (2017) for a live video of the Bozo Challenge competition day. The deliverables for the company visit project are unable to be shown in this paper due to submission formating and page length.

Figure 1. 5S Project Example 1 – Before

Figure 2. 5S Project Example 1 – After

Figure 3. 5S Project Example 2 – Before

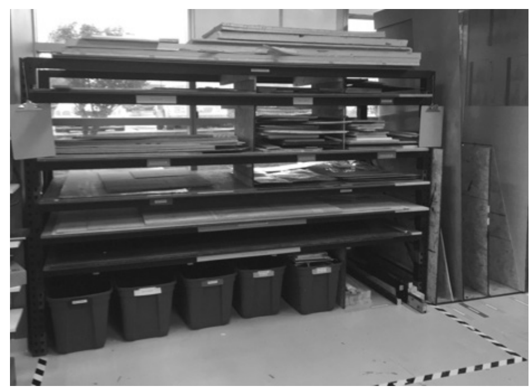

Figure 4. 5S Project Example 2 – After

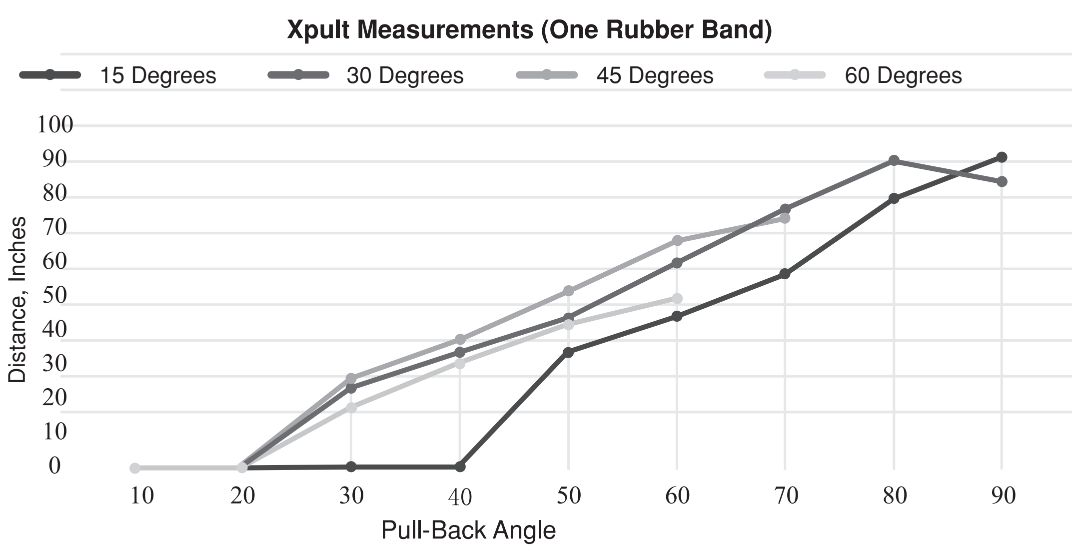

Figure 5. Bozo Challenge DOE Chart Example 1

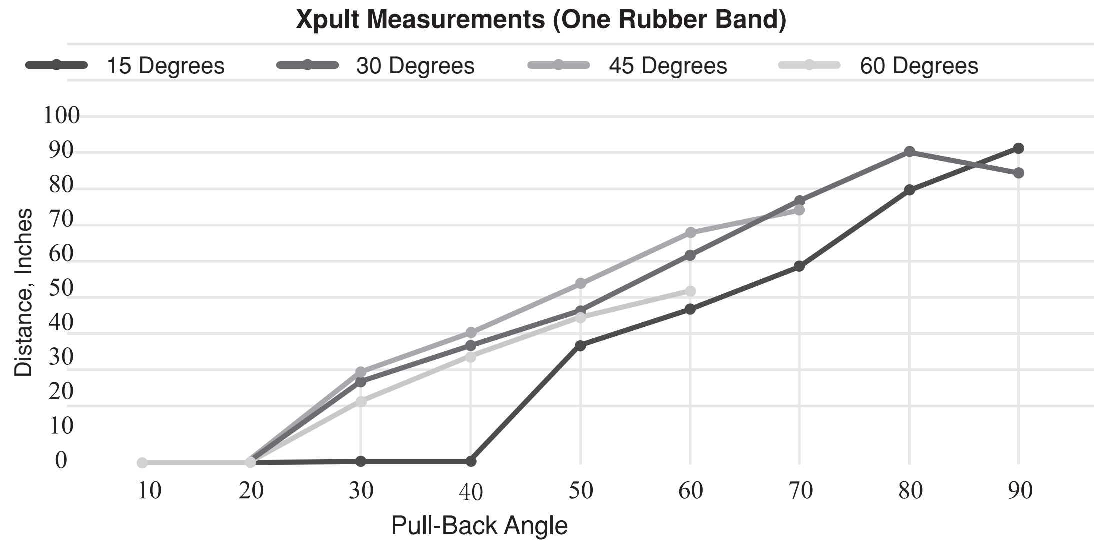

Figure 5. Bozo Challenge DOE Chart Example 1

TABLE 7. Bozo Challenge DOE Spreadsheet Example

Start Angle	Launch Angle	Rubberband Configuration #					
		1	2	3	4	5	6
0	20	X	X	X	X	X	X
	40	X	X	X	X	X	X
	60	X	X	X	X	X	X
	80	X	X	X	X	X	X
	100	X	X	X	X	X	X
	120	X	X	X	X	X	X
15	20	X	X	X	X	X	X
	40	X	X	X	X	X	X
	60	X	X	X	X	X	X
	80	X	X	X	X	X	X
	100	X	X	X	X	X	X
	120	X	X	X	X	X	X
30	30	X	1	X	X	X	X
	40	X	2	X	X	X	X
	50	X	3	X	X	X	X
	55	X	4	X	X	X	X
	60	X	X	X	X	X	X
	80	X	X	X	X	X	X
45	20	X	X	X	X	X	X
	40	X	X	X	X	X	X
	52.5	X	5	X	X	X	X
	60	X	6	X	X	X	X
	80	X	X	X	X	X	X
	120	X	X	X	X	X	X
60	22.5	X	1	X	X	X	X
	32.5	X	2	X	X	X	X
	40	X	3	X	X	X	X
	47.5	X	4	X	X	X	X
	53.5	X	5	X	X	X	X
	60	X	6	X	X	X	X
75	20	X	X	X	X	X	X
	40	X	X	X	X	X	X
	60	X	X	X	X	X	X
	80	X	X	X	X	X	X
	100	X	X	X	X	X	X
	120	X	X	X	X	X	X

DISCUSSION

Published literature whose authors studied quality-focused courses and the instructional techniques and/or methods used in the classroom is limited. However, the importance of educating ET students in quality control theory and application is of great importance because all industries must control the quality of their services or goods. In no other industry is this more relevant than in manufacturing, where effective quality control can be a cornerstone to success. The transformation of MET 45100 to a student-centered learning environment is a direct response to improve Purdue Polytechnic New Albany quality control curriculum so it may better align with the needs of graduating students and industry.

> "Businesses clearly need socially well-adapted, communicative employees who are eager to learn, involved and willing to work actively toward a permanent improvement of their organizations more than they needs theoretically trained quality technicians" (Kemenade & Garre, 2000, p. 35).

The idea that active learning and PBL can strengthen students' knowledge and skills is not a new concept. Even decades old quality related literature recommends combining theoretical knowledge with practical situations (Kemenade & Garre, 2000), and that "applied quality concepts should be added to basic quality control curricula at the college level" (Callahan & Strong, 2004, p. 45). However, there remains a need for comparison studies investigating the implementation of teaching-centered and learning-centered paradigms in quality courses. A similar request is made by Callahan and Strong (2004):

> A comparison of student skills after completing a more traditional lecture-based course versus a more applied course as suggested by this study would be of interest. This information could help determine the potential for improving quality control skills by revising course content and structure (p. 53).

The resources supplied and the data revealed in this paper offer a starting point to such a request. However, the authors advise caution with the course metrics and students' comments. The mean scores for course and instructor satisfaction increased by 23.08 percent and 17.07 percent respectively, and students' perception that lab content was worthwhile part of the course increased by 17.07 percent. The given sample of student comments also suggest that students' perception of quality is a dry subject to study and that active learning can have a positive impact. The data suggests a learning-centered paradigm as the more popular and satisfying approach to quality-focused courses; however, bias is most likely present in the data.

A more formal evaluation should take place. Researchers need to sustain course topics, objectives, and assessment points (e.g., written exams, practical exams) consistent across both educational paradigms. Measuring students' quality knowledge and skill level with common quality tools/techniques (e.g., DOE, statistical process control) at the beginning and end of the course would also need to take place. Thus, researchers would need to create a valid and reliable instrument to do so, as the authors did not locate one during their review of the literature.

Limitations

"The results of this study are limited in many ways. Generalization of findings to other colleges and universities should be approached with caution, as … students participating in the study were not random" (Cabrera, Colbeck, & Terenzini, 2001, p. 341). The sample size for all three offerings was small so generalizability should be limited; however, the authors strongly believe that the project success and student satisfaction achieved are repeatable at other institutions of higher education. Statistical analysis between the groups (i.e., three course offerings) did not take place due to a variety of reasons. First, the creation and use of a valid and reliable measurement instrument(s) would need to occur.

Second, the authors did not plan a controlled research study prior to the first course offering. There is also only one data point for the teaching-centered paradigm approach. Either a third instructor taught MET 45100 prior to Spring 2015 or data was no longer available to analyze.

Finally, if statistical analysis of the groups is to occur, it is often more favorable to use a more objective measurement than student self-reporting (i.e., course evaluations). However, research suggests that self-report measures of learning can be used as valid objective measures (Cabrera et al., 2001). Hayek, Carini, O'Day, and Kuh (2002), stated that generally five conditions need to be present:

1. The information requested is known to respondents
2. The questions are phrased clearly
3. The questions refer to recent activities
4. The respondents think the questions merit a serious and thoughtful response
5. Answering the questions does not threaten, embarrass, or violate the privacy of the respondent or encourage the respondent to respond in socially desirable ways

CONCLUSION

In conclusion, this paper provides a review of two paradigms of education, and the transition of a manufacturing quality control for ET students from teaching-centered to learning-centered. In writing this case study, the authors had no scientific pretensions but above all wanted to increase awareness and access to teaching materials. The given sample outputs from the course offerings support the general assumption that students consider quality, as a dry subject to learn and that they prefer a more student-centered approach (e.g., PBL) to a manufacturing quality control course. In hopes of further adoption of student-centered instructional techniques in quality-focused courses, the authors have shared all PBL resources. Finally, there is much opportunity for further studies investigating the impacts of different paradigms of education used in quality courses.

Dr. Rustin Webster *is an Assistant Professor of Mechanical Engineering Technology at Purdue University, New Albany, where he specializes in mechanical engineering and computer graphics technology.*

Dr. Matthew Turner *is an Assistant Professor of Electrical and Computer Engineering Technology at Purdue University, New Albany, where he specializes in the areas of power systems and controls.*

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APPENDIX

MET 451: MANUFACTURING QUALITY CONTROL

5S Project

I. 5S Overview

This semester you will embark on 5S classroom, lab, and workplace organization as part of a lean implementation (i.e. creating value and eliminating waste). 5S is a five-step proces in which each step is a prerequisite for the next. The following table provides a quick reference description of each *S*, including the actual meaning of the Japanese *S* as well as the anglicized version.

II. Project Overview

This task will be a group-based project, where each individual team member is expected to contribute equally. To ensure equal workload, each group member will complete a peer evaluation survey at completion. Group assignment was randomized.

This task will take place in the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363. Two different *bubbles* have been identified for 5S application and each will be assigned to a group. The *bubbles* are as follows:

B1. Flat stock (large)

B2. Flat stock (small) and round stock

During each *S* step, the group is responsible to involve and coordinate with the required faculty and/or staff, as needed, for step completion.

It is expected that during certain steps that materials will need to be purchased. It is the group's responsibility to provide a detailed and professional bill of materials (BOM), including at a minimum part numbers, quantities, preferred source of supply, SKUs, and unit and total pricing (including shipping) to the instructor. Each group has an initial budget of $250.00. If additional funds are needed it is the group's responsibility to submit the request to the instructor and provide justification in a timely fashion. It is encouraged that local supply sources be used, such as, Harbor Freight, Home Depot, and Lowes. If online suppliers are targeted, such as, McMaster-Carr or Amazon Prime, please beware of shipping times and it is the group's responsibility to complete the project on time.

All purchases must be made directly by the instructor, no reembursments allowed

III. Deliverables

1. Proposal including BOM
    - Group submission
    - Proposal should be no more than one page (not including BOM)
    - Must use statewide letterhead (Blackboard-Projects Folder)

Japanese "S"	Japanese Meaning	Anglicized Version
Seiri	Remove all items from the workplace that are not immediately needed for the work.	Sort
Seiton	Place needed items (material, information, tools) in a location that supports the worker.	Straighten (set in order)
Seiso	Make the workplace spotless, free of contaminants, dirt and foreign material	Shine (scrub and sweep)
Seiketsu	Create a standard means for keeping the workplace clean and orderly	Standardize
Shitsuke	Make a commitment to order and cleanliness.	Sustain

- Includes details for each S step implementation, including but NOT limited to strategies, fund usage, and faculty/staff point of contacts (POC).
- It is encouraged to deliver as much detail as possible for project success.

2. Team presentation
   - Group submission
   - Given during class time
   - Slides submitted to Blackboard
   - 30 minutes max, including 5-10 minutes of Q&A
   - Must use Polytechnic-Slide Templates (Blackboard-Projects Folder)
   - Includes *preliminary* before and after images and/or videos for each *S* step, budget breakdown, and project summary, which could include but NOT limited to strategies used, lessons learned, 5S tips, inputs and outputs, outcomes, and faculty/staff POCs.

Criteria	Levels of Achievement			
	Exceeds Expectations	Good	Lacking	Seriously Deficient
Graphical Presentation	2.7 to 3 points Demonstrates high level of organization, balance, and audience engagement. The visual aids greatly enhance the presentation and never contain misspellings and grammatical errors. Presentation length was within the given time limits and a question/answer session was held. The correct PowerPoint template was used. Exceeds or meets project requirements for presentation.	2.4 to 2.7 points Demonstrates moderate level of organization, balance, and audience engagement. The visual aids somewhat enhance the presentation and rarely contain misspellings and grammatical errors. Presentation length was within the given time limits and a question/answer session was held. The correct PowerPoint template was used. Meets project requirements for presentation.	2.1 to 2.4 points Demonstrates low level of organization, balance, and audience engagement. The visual aids very little enhance the presentation and sometimes contain misspellings and grammatical errors. Presentation length was not within the given time limits and a question/answer session was not held. The incorrect PowerPoint template was used. Does no meet all project requirements for presentation.	0 to 2.1 points Demonstrates no level of organization, balance, and audience engagement. The visual aids do not at all enhance the presentation and often contain misspellings and grammatical errors. Presentation length was not within the given time limits and a question/answer session was not held. The incorrect PowerPoint template was used. Does no meet project requirements for presentation.
5S Solution	2.7 to 3 points 5S solution is complete, functional, and contains high levels of value-added for the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363. Exceeds or meets project requirements for 5S solution.	2.4 to 2.7 points 5S solution is complete, functional, and contains moderate levels of value-added for the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363. Meets project requirements for 5S solution.	2.1 to 2.4 points 5S solution is incomplete, nonfunctional, and contains no levels of value-added for the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363. Does not meet project requirements for 5S solution.	0 to 2.1 points 5S solution is incomplete, nonfunctional, and contains low levels of value-added for the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363. Does not meet all project requirements for 5S solution.

5S Steps	2.7 to 3 points Demonstrates high level of knowledge of the 5S process. All five steps (i.e. sort, straighten, shine, standardize, sustain) of the 5S process and safety are included in the graphical presentation and lab solution. Exceeds or meets project requirements for each 5S step.	2.4 to 2.7 points Demonstrates moderate level of knowledge of the 5S process. Many of the five steps (i.e. sort, straighten, shine, standardize, sustain) of the 5S process and safety are included in the graphical presentation and lab solution. Meets project requirements for each 5S step.	2.1 to 2.4 points Demonstrates low level of knowledge of the 5S process. A few of the five steps (i.e. sort, straighten, shine, standardize, sustain) of the 5S process and safety are included in the graphical presentation and lab solution. Does not meet all project requirements for each 5S step.	0 to 2.1 points Demonstrates no level of knowledge of the 5S process. None of the five steps (i.e. sort, straighten, shine, standardize, sustain) of the 5S process and safety are included in the graphical presentation and lab solution. Does not meet project requirements for each 5S step.
Final Report	2.7 to 3 points Demonstrates high level of organization, focus, sentence fluency, and writing conventions. The paper contains no errors in capitalization or punctuation. The paper is exceptionally easy to read. The correct Word template was used. Exceeds or meets project requirements for the final report.	2.4 to 2.7 points Demonstrates moderate level of organization, focus, sentence fluency, and writing conventions. The paper contains a few errors in capitalization or punctuation. The paper is easy to read. The correct Word template was used. Exceeds or meets project requirements for the final report.	2.1 to 2.4 points Demonstrates low level of organization, focus, sentence fluency, and writing conventions. The paper contains some errors in capitalization or punctuation. The paper is difficult to read. The correct Word template was not used. Does not meet all project requirements for the final report.	0 to 2.1 points Demonstrates no level of organization, focus, sentence fluency, and writing conventions. The paper contains many errors in capitalization or punctuation. The paper is difficult to read. The correct Word template was not used. Does not meet project requirements for the final report.

- Team presentation slides should be visual and treated like an executive summary

3. Final report
    - Group submission
    - No page limit
    - Must use statewide letterhead (Blackboard-Projects Folder)
    - .pdf submitted to Blackboard
    - Includes *final* before and after images for each *S* step, budget breakdown, and project summary, which should include but NOT limited to strategies used, lessons learned, 5S tips, inputs and outputs, outcomes, and faculty/staff POCs.
    - Report should contain **greater details, exploration, and discussion** than team presentation slides
4. Peer evaluation
    - Individual Blackboard submission

IV. Due Dates

1. Proposal including BOM: 9:30 am, Wednesday, 14th September 2016
2. Team presentations: 9:30 am, Wednesday, 28th September 2016
3. Final report: 11:59 pm, Monday, 3rd October 2016
4. Peer evaluation: 11:59 pm, Monday, 3rd October 2016

V. Assessment

1. Proposal will be based on 0 to 5 points.
2. Peer evaluation will be based on 0 to 1 point.
3. 5S project will be based on 0 to 12 points and use the above rubric

MET 451: MANUFACTURING QUALITY CONTROL

Bozo Challenge Project

I. Project Overview

This task will be a group-based project, where each individual team member is expected to contribute equally. To ensure equal workload, each group member will complete a peer evaluation survey at completion. Group assignment was randomized.

Teams will be given two full classroom periods (4 hours) to work on the project but it is anticipated that a minimal of 10-20 additional hours will be needed to satisfy project requirements and instructor expectations.

The objective of the project is to provide students an active and enjoyable opportunity to study design of experiments (DOE), statistics, variation, process capability, etc.

Teams shall fully complete the experiments in the three Xpult instructional documents (i.e. basic, highered, and advanced). Not doing so will result in poor results during the challenge.

II. Bozo Challenge Rules

1. Shall only use equipment provided in Xpult kits and by instructor besides the following:
   - Teams may design and rapid prototype part(s) to control variability in the connection between the Xpult arm and Xpult base
   - Teams may design and rapid prototype part(s) to control variability in the connection between the buckets and red connection strip (i.e. button snaps)
   - Shall only use 3D printers and lasers in the Paul W. Ogle Foundation Mechanical Engineering Technology Advanced Manufacturing Lab, room N1363
   - Once a team makes their first attemp during the Bozo Challenge they may not move, remove, and/or modify the designed/rapid prototyped part(s)
2. No modifications allowed to Xpult ki components/parts
3. Can use either ball type
4. Can use any combination of variables (i.e. pull back angle, number of rubber bands, Xpult starting position, etc.)
5. Ball must be launched by Xpult (i.e. no human assistance besides setup and the act of pulling arm back)
6. Ball may not hit any object other than current target bucket to be counted as a made basket (i.e. no bounce in or ricochet)
7. All parts of the Xpult must be behind the launch line during the challenge
8. Buckets and launch line will be placed on the top side of the tables in N1136
9. Table tops will be 28.50” from the floor an 91.50” from the ceiling
10. Only one make per bucket counts towards grading
11. Using official Bozo Bucket Bonanza Gran Prize Game equipment
12. Using official Bozo Bucket Bonanza Gran Prize Game instructions besides the following exceptions:
    - Replacing the human thrower with an Xpult
    - Team gets three shots at each bucket in order, starting with the firs
    - If ball is shot into the target bucket and bounces out it is recorded as a made bucket

III. Bozo Challenge Measurements

1. Launch line to center of first bucket = 18.75
2. 1st bucket to 2nd bucket = 11.75”
3. 1st bucket to 3rd bucket = 23.50”
4. 1st bucket to 4th bucket = 34.875”
5. 1st bucket to 5th bucket = 46.50”
6. 1st bucket to 6th bucket = 58.00”
7. Launch line to center of grand prize cup = 120”
8. Official Bozo Bucket diameter = 5.875
9. Official Bozo Bucket height = 6.437
10. Grand Prize Cup diameter = 9.4375”
11. Grand Prize Cup height = 7.00”

IV. Deliverables

1. Bozo Challenge
   - Team competition (all members present)
   - Conducted during class time
   - Upload all DOE resources (i.e. spreadsheets) and CAD files t Blackboard
2. Peer evaluation
   - Individual Blackboard submission

V. Due Dates

1. Bozo Challenge: 9:30 am, Wednesday, 2nd November 2016
2. Peer evaluation: 11:59 pm, Wednesday, 9th November 2016

VI. Assessment

1. Peer evaluation will be based on 0 to 1 point.
2. Bozo Challenge project will be based on 0 to 12 points and use the following rubric:
   - 100% = 6 buckets made
   - 90% = 5 buckets made
   - 80% = 4 buckets made
   - 70% = 3 buckets made
   - 60% = <3 buckets made
3. Grand prize
   - The Grand Prize Cup will be in line with the Official Bozo Buckets. If a team akes it 5 consecutive times in the grand prize cup I will buy them lunch (<$7 per person).

MET 451: MANUFACTURING QUALITY CONTROL

Company Visit Project

I. Project Overview

As part of the company visit project, Company Visit Teams (CVT) will be formed. CVTs will apply their knowledge of quality to analyze a company's quality culture and make recommendations to improve upon the design of the quality systems they have observed. CVTs must also describe how their recommendations will impact quality improvement at the particular facility.

This task will be a group-based project, where each individual team member is expected to contribute equally. To ensure equal workload, each group member will complete a peer evaluation survey at completion. Group assignment was randomized.

This task will take place outside of the classroom and outside of our normal meeting time. CVTs shall propose two potential companies to visit. After instructor approval is given, CVTs shall coordinate a tour/visit. The CVTs shall target the quality department and/or personnel during the tour. CVTs shall learn as much as possible about the company's quality culture, policies, procedures, qualifications, tools, etc. Request to take photos and/or videos during the tour.

The objective of the project is to gain enough knowledge to analyze and then make recommendations concerned with quality management.

II. Deliverables

1. Proposal
   - Group submission
   - Company Visit Proposal submitted to Blackboard
2. Team presentation
   - Group submission
   - Given during class time
   - Slides submitted to Blackboard
   - 15 minutes max, including 5-10 minutes of Q&A
   - Must use Polytechnic-Slide Templates (Blackboard-Projects Folder)
   - Team presentation slides should be visual and treated like an executive summary
3. Peer evaluation survey
   - Individual Blackboard submission

III. Due Dates

1. Proposal: 9:30 am, Monday, 3rd October 2016
2. Team presentations: 9:30 am, Wednesday, 30th November 2016
3. Peer evaluation: 11:59 pm, Friday, 9th December 2016

IV. Suggested Slide Outline

A. Title
B. Company
   a. Name
   b. Location
   c. Executive statement (who they are and what they do)
   d. Logo included somewhere on the slide
C. Point of Contact (POC)
   a. Name
   b. Title
   c. Executive statement (who they are and what they do)
D. Observations
E. Observations Cont.
F. …
G. Recommendations
H. Recommendations Cont.
I. …
J. Conclusion

Note: shall include justifications for each recommendation

V. Assessment

1. Proposal will be based on 0 to 1 point.
2. Peer evaluation will be based on 0 to 1 point.
3. CVT project will be based on 0 to 6 points and use the following rubric:

Criteria	Levels of Achievement			
	Exceeds Expectations	**Good**	**Lacking**	**Seriously Deficient**
Graphical Presentation	2.7 to 3 points Demonstrates high level of organization, balance, and audience engagement. The visual aids greatly enhance the presentation and never contain misspellings and grammatical errors. Presentation length was within the given time limits and a question/answer session was held. The correct PowerPoint template was used. Exceeds or meets project requirements for presentation.	2.4 to 2.7 points Demonstrates moderate level of organization, balance, and audience engagement. The visual aids somewhat enhance the presentation and rarely contain misspellings and grammatical errors. Presentation length was within the given time limits and a question/ answer session was held. The correct PowerPoint template was used. Meets project requirements for presentation.	2.1 to 2.4 points Demonstrates low level of organization, balance, and audience engagement. The visual aids very little enhance the presentation and sometimes contain misspellings and grammatical errors. Presentation length was not within the given time limits and a question/answer session was not held. The incorrect PowerPoint template was used. Does no meet all project requirements for presentation.	0 to 2.1 points Demonstrates no level of organization, balance, and audience engagement. The visual aids do not at all enhance the presentation and often contain misspellings and grammatical errors. Presentation length was not within the given time limits and a question/answer session was not held. The incorrect PowerPoint template was used. Does no meet project requirements for presentation.
Observations/ Recommend.	2.7 to 3 points Demonstrates high level of knowledge of quality management Many recommendations for improvement are presented from observations during site visit All recommendations are accompanied by justification. Exceeds or meets project requirements for CVT project	2.4 to 2.7 points Demonstrates moderate level of knowledge of quality management Some recommendations for improvement are presented from observations during site visit Some recommendations are accompanied by justification. Meets project requirements for CVT project	2.1 to 2.4 points Demonstrates low level of knowledge of quality management Few recommendations for improvement are presented from observations during site visit Few recommendations are accompanied by justification. Does not meet project requirements for CVT project	0 to 2.1 points Demonstrates no level of knowledge of quality management No recommendations for improvement are presented from observations during site visit No recommendations are accompanied by justification. Does not meet project requirements for CVT project

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Extending the Technology Acceptance Model to Improve Usage & Decrease Resistance toward a New Technology by Faculty in Higher Education

By Dan Siegel, Parul Acharya, and Stephen Sivo

ABSTRACT

The study analyzed why some university faculty resisted a new software program using a new model of motivation. The new model, called the Motivation Acceptance Model (MAM), was inspired by the technology acceptance model and the Commitment and Necessary Effort (CANE) model of motivation. This model was tested on faculty at a university who were resisting a new software program called Live-Text. Regression analysis was utilized to determine the relationship between variables of the MAM. The study demonstrates that the MAM accurately measured the relationship between professors' perceptions and their use of Live-Text. The research also suggests that perceived utility of Live-Text and users' attitudes toward Live-Text were statistically significant predictors of Live-Text use and that perceived ease of use also predicted whether the professors found Live-Text useful.

Keywords: Technology Acceptance Model, Motivation Acceptance Model, Resistance to Change, Live-Text

INTRODUCTION AND BACKGROUND

Employee resistance and low motivation to use new technology is a problem that continues to trouble business and educational organizations throughout the world (Ngafeeson, 2015). A Technology Acceptance Model (TAM) was designed to include additional behavior constructs to develop further understanding of technology acceptance. Users continue to struggle with new technology because technologies are constantly changing and there is increased pressure on employees to develop their skills so that their organizations can stay competitive. Meier, Ben and Schuppan (2013) examined employees' resistance to change and their attitude toward the adoption of electronic records system in an organization. They found that fear of losing work autonomy, social influence, and perceived quality of information significantly influenced employees' resistance to change. These authors explained that the "Technology Acceptance Model should be enhanced by introducing additional variables on the context of information communication technologies related to transformation" (p. 327). Research conducted by Sevier (2003) at Macalester College highlighted the need to overcome organizational resistance in academia as well. He stated "motivational measurements and strategies were used to create a sense of urgency that would overcome internal resistance in the organization" (p. 23). Lwoga and Komba (2015) investigated the factors that influenced students' intention to continue using web-based learning management system (LMS). They suggested in their article that resistance to change can be reduced if both faculty's and student's feedback are considered during the design, development, and implementation phase of a new technology or LMS.

The current literature on resistance to technology and solutions such as the TAM often ignore motivational elements that are fundamental to an employee's decision about whether or not to embrace a new technology. Motivational issues have led to numerous challenges for business and academic environments. Low motivation and resistance to technology is a growing problem in academic and business settings throughout the world. Live-Text is a web-based application that assists faculty and students to collaborate and share classroom learning materials and assignments as well as track student progress in an online course. Perspectives on Live-Text should be measured using a model that combines motivation with the acceptance of technology on an organizational level. Because there are few successful models that specifically address issues of technology acceptance and motivation on an organizational level, a solution would be to form a new hybrid model inspired by the TAM and the CANE model. The formation of a hybrid model is well supported by the literature because the TAM was built upon the premise that new constructs could be added. Motivation is a construct that must be addressed when considering whether a person will perform an action or undertake a new task. The Motivation Acceptance Model was developed in this study to blend previously tested theories on technology acceptance with fundamental motivational concepts to expand the literature on ways to successfully implement new technology in organizations. MAM was applied to the faculty at a large university with a new technology called Live-Text. Faculty was introduced, and faculty members could embrace or resist technology directly or passively (Petrini & Hultman, 1995). Even though many faculty members embraced Live-Text, many others either actively or passively resisted its implementation. The level of acceptance and the causes of resistance were determined to locate solutions to overcome resistance and encourage the successful implementation of Live-Text. This study aims to improve the understanding of why faculty resist new technology in a university setting and how motivation to use and acceptance of technology can be enhanced to help faculty succeed in adoption of Live-Text.

The research question for this study is, "What are the relationships between the components of the MAM as applied to its usefulness in getting faculty to use Live-Text? From this research question, the following hypotheses were derived (see Figure 1):

H1: An increase in positive attitude, perceived usefulness, perceived ease of use, and perception of organizational support toward Live-Text will result in a statistically significant increase in the use of Live-Text.

H2: An increase in perceived ease of use and perception of organizational support toward using Live-Text will result in a statistically significant increase in a positive attitude toward Live-Text.

H3: An increase in perceived ease of use and perceived organizational support of Live-Text will result in a statistically significant increase in perceived usefulness of Live-Text.

REVIEW OF LITERATURE

Technology Acceptance Model (TAM)

The TAM originated from Fishbein and Ajzen's (1975) theory of reasoned action. This theory suggests that a person's behavior is determined by his/her intention to perform the behavior and that this intention has, in turn, been a function of his/her attitude toward the behavior and his/her subjective norms (SN). Attitude and subjective norms have been shown to have a significant effect on behavioral intent and adoption of a new system (Punnoose, 2012; Schepers &Wetzels, 2007). By using Theory of Reasoned Action as a theoretical foundation, Davis (1985) created the TAM to focus on the domain of user acceptance of technology by replacing the attitudinal components of the theory with perceived ease of use (PEU) and perceived usefulness (PU). PEU is defined as the "degree to which the individual believes that using the system would require little or no mental and physical effort" (Davis, 1993, p. 477). PU is defined as the "degree to

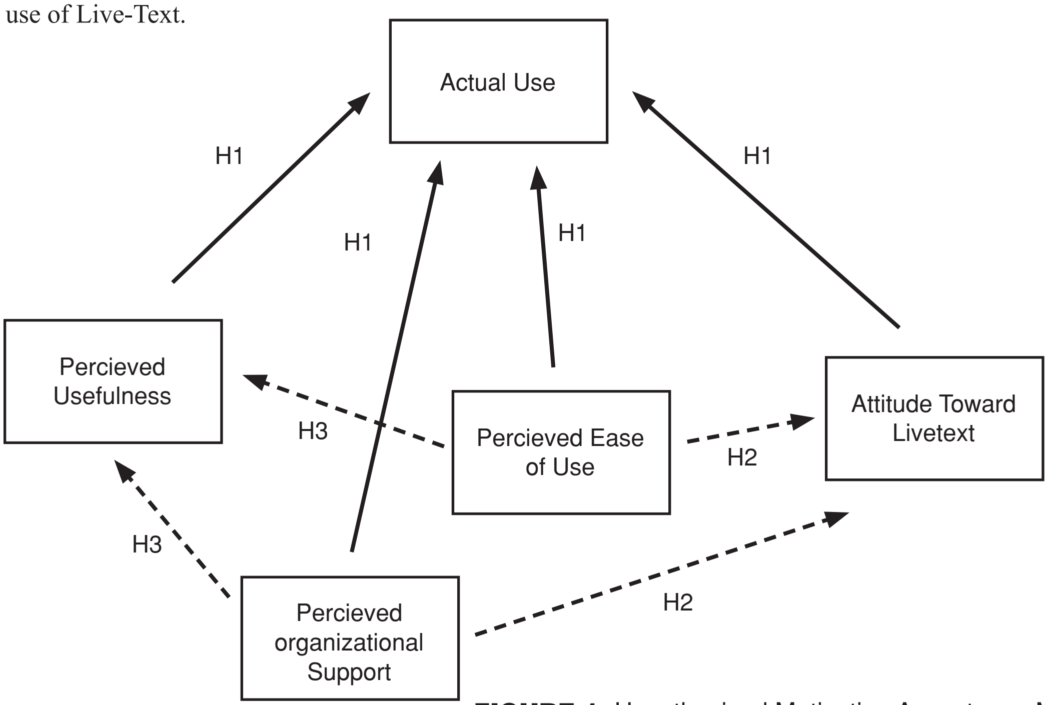

FIGURE 1: Hypothesized Motivation Acceptance Model

which an individual believes the use of a system could enhance job performance" (Davis, 1993, p. 477). The Technology Acceptance Model postulates that the intention to use technology is a function of perceived ease of use and perceived usefulness. Researchers have demonstrated that the intention to use a technology has been the strongest predictor of actual usage of technology. Intention to use a technology is more directly influenced by the individual's perception of its usefulness, even if people did not have a positive attitude toward using the technology (Teo, 2016; Tsai, 2011).

A TAM is the simplest, easiest, and most powerful measure of technology usage (Chen, Sivo, Seilhamer, Sugar, Mao, 2013; Pan, Sivo & Brophy, 2003; Teo, 2016; Tsai, 2011). Van der Heijden (2003) described the TAM as "a parsimonious, theoretically and empirically justified model that is intended to explain the acceptance of information systems" (p. 541). TAM is a popular model for explaining the behavior of technology users and has been empirically demonstrated to have high validity in many research contexts (Chau, 1996). Venkatesh, Morris, Davis, and Davis (2003) compared the explanatory power between models, with or without extensions, and found that the explanatory power of the TAM increased as extensions were added to it.

The TAM allows researchers to locate the causes of technology resistance by focusing on behavioral constructs. Resistance can be defined as the propensity "to remain unaffected or undamaged by something" (O'Neill, 2001, p. 1050). Many employees in mandatory environments may rebel against harsh systems through passive resistance, such as talk in the hallways, and active resistance, such as sabotage or quitting. The challenge in researching the concept of resistance is finding the cause of the resistance in the organization (Sevier, 2003). It must be addressed when seeking a solution to employees' resistance to technology. Both the nature of resistance and why it occurs deserve continued study because of the great impact technology has on organizations. Academic researchers must analyze factors related to training management and process implementation because the failure rate of these programs is high (Kotter, 1995). Gong, Xu, and Yu (2004) studied resistance to educational technology using the TAM by measuring teachers' technology acceptance using an expanded TAM that included computer self-efficacy as a behavioral construct. The research indicated that self-efficacy showed a strong direct effect on both perceived ease of use and intention to use. A strong relationship was found between computer self-efficacy on intention and users' perceived ease of use. Hsieh (2015) examined employee resistance to a new cloud computing technology among healthcare professionals. The results suggested, "it is important to incorporate user resistance in technology acceptance studies" (p.1).

Although research indicates strong validity in the TAM (Chau, 1996), some critics believe it is too simple and has a limited number of constructs to describe behaviors that are intrinsic to the person, such as motivation. Mathieson (1991) pointed out that the TAM does not provide detailed information, but general opinions about the users and the system. Venkatesh and Davis (2000) have discussed that although the TAM can help predict acceptance, it does not always help researchers understand and explain employee's acceptance of technology beyond attributing the system characteristics of ease of use and usefulness. TAM is not a descriptive model and does not provide diagnostic capabilities for finding flaws in the implementation of technology. Hence, there is the need to expand the model to find causes of technology resistance. Motivation has a strong relationship to goal achievement and the decision to learn and use a new program. Therefore, the authors propose to extend the TAM by using a motivational construct inspired by the CANE model of motivation. The CANE model is discussed next as an inspiration to expand the TAM to include motivation as an important aspect of new technology acceptance.

Commitment & Necessary Effort (CANE) Model of Motivation

The CANE model is based on Ford's (1992) motivational systems theory. It was developed by Clark (1998). The model describes motivation as "the organized interplay of three psychological functions that serve to direct, energize, and regulate goal-directed activity: Personal agency beliefs, emotional arousal processes, and task value" (Ford, 1992, p. 3). The original CANE model was intended to measure motivation in academic settings and has proven to be highly accurate in predicting academic behavior (Condly, 1999). The CANE model has three factors: personal agency (self-efficacy and support from organization), affect, and task value. Condly (1999) found that these three factors explained a substantial portion of employee' commitment in academic motivation.

Personal agency incorporates self-efficacy and the belief that the organization supports an employee in a task. These perceptions can be positive or negative, and they influence an individual's motivation to accept a new technology, such as Live-Text. The question regarding agency would be: "Can I do this task under these conditions?" Bandura (1977) believed that behaviors were the determinants of a person's beliefs and that only if someone believed a behavior was possible would that behavior be produced. Self-efficacy describes the inward perception of the question: "Can I do this task?" It is formed from a variety of individual experiences. Organizational support is critical because it influences motivation and technology acceptance. The attitudes and beliefs of other group members shape behavior to use technology through communication. Social interactions generate meaning and understanding of group behavior patterns in a virtual environment (Preece, 2001; Tsai, 2011). The altering of political and social dynamics in the organization can change, and the acceptance of new ideas can reduce motivation (Abduljalil & Zainuddin, 2015; Kent, 2015).

An employee's attitude toward a technology is described as affect or emotional arousal in the CANE model, and it consists of two components: emotion and mood. Emotion is an individual's feelings produced by the task. Emotions play a key role in blocking acceptance of information technology (Clark, 1998). Mood focuses on the feelings an individual brings to the task. Emotion can be either positive or negative. The user feels a positive or negative emotion toward a subject. This measurement is critical, because an individual may feel that he/she can use a new technology and that the new technology would be useful, but could, nevertheless, dislike it and therefore reject it.

The task value component from the CANE model of motivation is composed of three constructs: importance, interest, and utility. The CANE model defines the construct of importance as to how closely individuals identify themselves with the task. The question to be asked should be "Is this task important to me?" This construct will not be measured because it is unlikely that a respondent will personally identify with the online management software given the type of task in the study. Interest focuses on intrinsic rewards, such as enjoyment or curiosity, received by an individual engaged in a task (Clark & Estes, 2002). Interest leads to the internal motivation to overcome obstacles in the desire for an internal reward. The increase in internal motivation may ultimately lead to greater acceptance of technology. Utility addresses relevance that is subjective and individual to each user. Ford (1992) discussed the need for specific opportunities for the goal to be meaningful. These opportunities create meaning for the user and commitment to the new technology. The questions should be: "Is this worth my while?" and "Do I get anything out of this?" If the user perceives the task is valuable, then motivation and acceptance may ensue.

Motivation Acceptance Model (MAM)

The CANE model focuses on motivation but does not specify factors of technology acceptance. By itself, motivation is one factor in the acceptance of technology. A model derived from the fusion of the CANE model and the TAM may provide a better understanding of users' perceptions and their acceptance of the technology (Live-Text), because the former can explain how attitudes are influenced by motivational factors and the latter can provide information on the way users form attitudes based on technological characteristics. Past research has presented numerous examples of such expansions (Punnoose, 2012; Schepers &Wetzels, 2007; Tsai, 2011). However, there is limited research on the use of the TAM and motivational measures with academic faculty. As Davis (1993) demonstrated, technology acceptance is determined by a variety of motivators. In this study, the authors incorporated the robust CANE model into the TAM model to account for the motivational aspect of technology acceptance. This is congruent with the assertion that TAM must be integrated into a model that includes other variables such as change processes to functionally measure motivation. The TAM and the CANE model have been extensively tested and validated in areas other than instructional technology. The proposed model is the MAM. The MAM combines factors of the CANE model and TAM to include actual use (AU), amount of actual use (AAU), attitude toward Live-Text (AT), familiarity with Live-Text (F), perceived usefulness (PU), perceived ease of use (PEU), and perception of organizational support (POS).

METHODOLOGY

Participants

The study participants were faculty who were selected from four major departments in the College of Education and were either utilizing Live-Text or had the intention of utilizing it. Of the 127 faculty members who were contacted, 59 completed the survey on whether they used Live-Text. Out of the 59 faculty members, 25 completed the user survey and 34 completed the nonuser survey. Out of the total 59 faculty who participated, 20 respondents (33.9%) were between the ages of 51 and 60, 30 respondents (66.1%) were females, 49 respondents (83.1%) were White, 44 respondents (74.6%) had worked in education for more than 6 years, and 26 respondents (47.5%) had been affiliated with the university for more than 6 years.

Data Collection Instrument

Faculty members were given a survey depending on whether they were users or nonusers of Live-Text. The survey was developed based on the pertinent literature to measure their perceptions of Live-Text. All the participants knew about Live-Text. The surveys for users had more questions than nonusers because more information could be acquired from the former than latter. Information from users included frequency and familiarity of Live-Text. The surveys were constructed using a 5-point Likert-type scale (1 as “Strongly Disagree”, 2 as “Disagree”, 3 as “Neither Agree nor Disagree”, 4 as “Agree”, 5 as “Strongly Agree”, and N/A as “Not Applicable”) measuring the faculty members’ perception on the variables of MAM in the context of Live-Text and demographics questions (age, gender, ethnicity, length of time worked in the field and length of time faculty has been affiliated with the university). The survey also utilized Yes or No questions to determine who is using Live-Text and their familiarity with the functions of Live-Text. The survey consisted of the following measures:

- Actual Use (AU): AU measures “the individual’s behavior regarding the new system” (Davis, Bagozzi, & Warshaw, 1989). It measured whether a faculty is currently using Live-Text. AU was measured using one item with the statement reading “I use Live-Text” and the choices of “Yes” or “No.”
- Amount of Actual Use (AAU): It measured the frequency and duration of Live-Text use by the faculty. The frequency self-report scale was measured on a scale with 1 as “Less than once a week,” 2 as “Once a week,” 3 as “Twice a week,” 4 as “Three times a week,” and 5 as “More than three times a week.” The duration self-report scale was also measured on a scale with 1 as “Less than 30 minutes,” 2 as “Between 30-60 minutes,” 3 as “Between 60-90 minutes,” 4 as “Between 90-120 minutes,” and 5 as “More than 120 minutes.”
- Attitude toward Live-Text (AT): It measured how a faculty member feels toward Live-Text. Six items were used to measure AT (three items each for users and nonusers adapted from Davis, 1993).
- Familiarity with Live-Text (F): It measured the different functions utilized by faculty in Live-Text. The respondents were asked if they were familiar with or used Live-Text: an array of 26 items were used to measure having “Yes” and “No” responses.
- Perceived Usefulness (PU): In this study, PU measured faculty’s perception of the usefulness and the level of serviceability (utility) Live-Text provides. Seven items were used to measure PU (nine items for users and eight items for nonusers adapted from Davis, 1989).
- Perceived Ease of Use (PEU): In this study, PEU measured faculty members’ perception of how easy it is to use Live-Text and the perception of their own personal technological capabilities compared to how difficult they think Live-Text is to use (whether they have already used it because questions are based on perceptions. Seven items were used to measure PEU (four items for users and two items for nonusers adapted from Davis, 1989).

- Perception of Organizational Support (POS): It measured the faculty's perception of how supportive the university is toward the respondents' use and implementation of Live-Text. It also measures professors' perception on university's support for students utilizing Live-Text. Twenty items were used to measure POS.

Data Analysis

Data analysis was conducted in five stages. In the first stage, internal consistency reliability analysis (Cronbach's alpha reported in Table 1) was conducted on the variables under investigation in SPSS. In the second stage, structural equation modeling (SEM) was used to test the direct and indirect relationships in the hypothesized theoretical model. The model was evaluated in statistical analysis software to find the pathway coefficients through multiple regressions. The third stage involved comparing Live-Text users and nonusers on the variables of interest by using independent-sample t-tests. In the fourth stage, MAM was reevaluated by using the number of actual-use variables that determined how each variable (PEU, POS, AT, and PU) influenced the way each user utilized Live-Text. Only users were measured. The actual-use variables included how often a respondent used Live-Text (e.g., monthly, weekly, or daily), how long each use lasted (minutes or hours), and how many times the respondent used Live-Text during the semester. In the fifth stage, descriptive statistics were calculated for the Live-Text functions that users are aware of and whether they use these functions.

RESULTS

The results section is arranged around the three hypotheses tested in the study followed by the independent t-test and Live-Text frequency results. The means, standard deviations and Cronbach's alpha coefficients of the measures are presented in Table 1. All the coefficients exceed 0.80. These four measures were deemed acceptable and valid. The path coefficients for the SEM is provided in Figure 2.

TABLE 1: Internal Consistency Reliability (Cronbach's Alpha)

Instrument	Cronbach's alpha	M	SD
Percieved usefulnes	.97	5.05	6.77
Precieved ease of use	.93	4.71	5.69
Perception of organizational support	.88	11.76	4.67
Attitude toward	.99	3.37	4.50

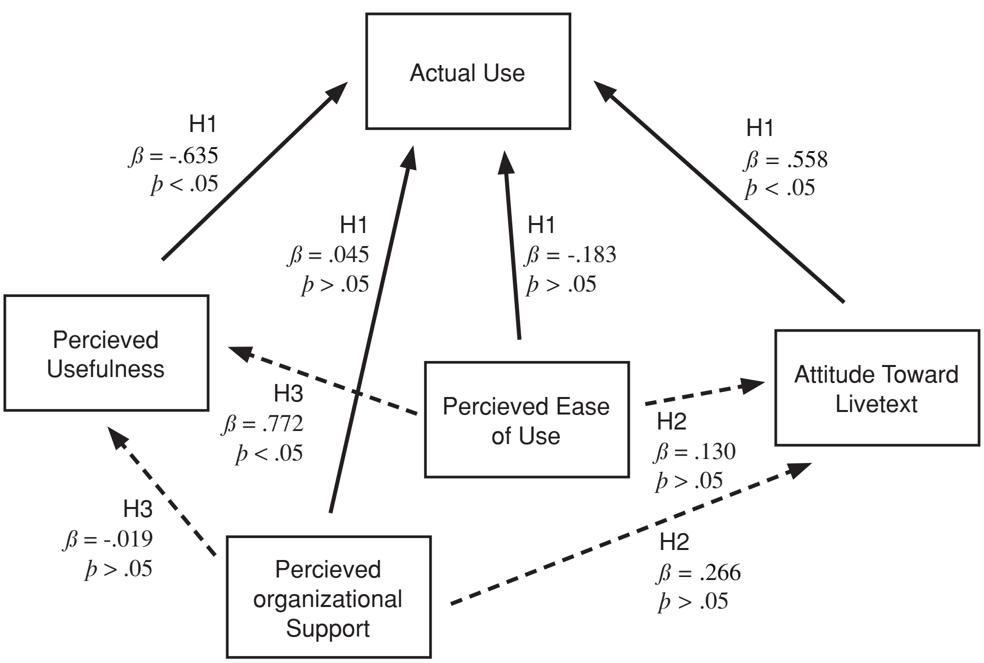

FIGURE 2: Path Coefficients for the Structural Equation Model

Hypothesis 1 Results

The independent variables in the SEM were AT, PU, PEU and POS and the dependent variable was AU. Regression analysis revealed that the model was statistically significant and predicted AT ($F_{4,58}$ = 55.1, $p < .05$) providing support for hypothesis 1. The R^2 for the model was 0.80, and the adjusted R^2 was 0.79. PEU (t = – 2.24, $p <$ .05), PU (t = –6.84, $p < .05$) and AT (t = 7.28, p < .05) were a statistically significant predictor of AU, whereas POS (t = 0.71, $p > .05$) was not a strong statistically significant predictor for AU.

Hypothesis 2 Results

The independent variables in the SEM were PEU and POS and the dependent variable was AT. Regression analysis revealed that the model was statistically significant and predicted AT ($F_{4,58}$ = 3.98, $p < .05$) providing support for hypothesis 2. R^2 for the model was 0.12, and the adjusted R^2 was 0.09. PEU (t = 1.22, $p > .05$) and POS (t = 2.00, $p > .05$) were a statistically significant predictor of AT.

Hypothesis 3 Results

The independent variables in the SEM were PEU and POS and the dependent variable was PU. Regression analysis revealed that the model was statistically significant and predicted PU of Live-Text ($F_{4,58}$ = 42.95, $p < .05$) providing support for hypothesis 3. R^2 for the model was 0.61, and the adjusted R^2 for the model was 0.59. PEU (t = 8.81, $p < .05$) was a strong predictor of PU whereas POS (t = –0.18, $p > .05$) was not a statistically significant predictor of PU.

Independent t-Test Results

A series of t-tests were conducted to compare between users and nonusers within the MAM framework. The analyses focused on comparison of AT, PEU, POS, and PU. A t-test was used to compare PU of Live-Text between users and nonusers. A statistically significant difference (t_{58} = 7.08, $p < .05$) was found between users and nonusers in their PU of Live Text. On average, users (M = 1.70, SD = 0.66) displayed higher levels of PU than nonusers (M = 0.77, SD = 0.29). A t-test was used to compare PEU of Live-Text between users and nonusers. A statistically significant difference (t_{58} = 8.10; $p <$ .05) was found between users and nonusers. On average, users (M = 2.09, SD = 0.59) displayed higher levels of PEU than nonusers (M = 1.11, SD = 0.34). A t-test was used to compare attitude toward Live-Text between users and nonusers. No statistically significant difference (t_{58} = -0.67; $p > .05$) was found between users (M = 1.33, SD = 0.55) and nonusers (M = 1.42, SD = 0.53) in their attitude toward Live-Text. A t-test was used to compare POS for Live-Text between users and nonusers. No statistically significant difference (t_{58} = -0.34; $p > .05$) was found between users (M = 2.75, SD = 0.48) and nonusers (M = 2.70, SD = 0.58).

Live-Text Frequency Usage Results Based on Date

Multiple regression analysis was performed between the Live-Text frequency (dependent variable) based on date and AT, PEU, POS and PU (independent variables). The model was statistically significant ($F_{4,58}$ = 47.77, $p < .05$) and predicted Live-Text usage based on dates. R^2 for the model was 0.78, and the adjusted R^2 for the model was 0.76. Attitude toward Live-Text (t = –7.03, $p < .05$) and PU (t = 7.09, $p < .05$) significantly predicted Live-Text usage, whereas PEU (t = 1.25, $p > .05$) and POS (t = 0.05, $p > .05$) did not. Respondents who said they perceived Live-Text as useful were more likely to use it. Interestingly, attitude toward Live-Text (t = –7.03, $p < .05$) was an inverse predictor of how often a user would use Live-Text on a daily or weekly basis.

Live-Text Frequency Usage Results Based on Semester

Multiple regression analysis was performed between the Live-Text frequency (dependent variable) based on semester and AT, PEU, POS and PU (independent variables). The model was statistically significant ($F_{4,58}$ = 32.68, $p < .05$) and predicted Live-Text usage. R^2 for the model was 0.62, and the adjusted R^2 for the model was 0.60. Attitude toward Live-Text (t = –4.77, $p <$ .05), PEU (t = 2.55, $p < .05$) and PU (t = 3.16, $p < .05$) significantly predicted Live-Text usage, whereas POS (t = -0.04, $p > .05$) did not.

Live-Text Frequency Usage Results Based on Duration

Multiple regression analysis was performed between the Live-Text frequency (dependent variable) based on duration and AT, PEU, POS and PU (independent variables). The model was statistically significant ($F_{4,58}$ = 22.36, $p < .05$) and predicted Live-Text usage. R^2 for the model was 0.78, and the adjusted R^2 for the model was .76, Figure 5 displays the standardized regression coefficients (β) for each variable. Attitude toward Live-Text (t = –7.03, $p < .05$) and PU (t = 7.09, $p < .05$) were significantly predicted Live-Text usage whereas PEU (t = 1.25, $p > .05$) and POS (t = 0.05, $p > .05$) did not. Respondents who said they perceived Live-Text as useful were more likely to use it. Interestingly, attitude toward

Live-Text ($t = -7.03$, $p < .05$) was an inverse predictor of how often a user would use Live-Text on a daily or weekly basis.

Frequency of Usage for Each Live-Text Function

Faculty members utilized ($n = 25$) the following Live-Text functions in order of decreasing frequency: Electronic portfolio (88%, $n = 22$), Review Function (88%, $n = 22$), Share Function (64%, $n = 16$), Rubric Builder (44%, $n = 11$), Assessment Reporting Tools (32%, $n = 8$), Standards Library (32%, $n = 8$), Standards Stamper (28%, $n = 7$), Lesson Planner (28%, $n = 7$), Forms Function (28%, $n = 7$); Template Designation (24%, $n = 6$), Exhibit Center (20%, $n = 5$), Project Design (12%, $n = 3$), and the United Streaming Video Resources (8%, $n = 2$) (Table 2).

DISCUSSION

One of the most critical challenges faced by management is the adoption of technology. Institutes of higher education spend significant amounts of resources to introduce new technologies for the benefit of faculty and students, but the adoption rates are poor (Anderson, 2012; Bousbahi & Alrazgan, 2015). New technologies that are not fully adopted increase the overall operational and logistical costs that may ultimately lead to discontinuation of the new technology, thereby depriving faculty, students, and the institution of its benefits. The purpose of this study was to investigate the correspondence between faculty members' attitude toward the use of Live-Text and their actual use of Live-Text by

TABLE 2: Frequency of Live-Text Function Usage

Name of function	Number of function users	Percentage of the sample
I am familiar with the Electronic Portfolio	25	100%
I am familiar with the Standards Stamper	12	48%
I am familiar with the Standards Library	13	52%
I am familiar with the Lesson Planner	19	75%
I am familiar with the Rubric Builder	22	88%
I am familiar with the Assessment Reporting Tools	15	60%
I am familiar with the Template Designation	15	60%
I am familiar with the Forms Function	8	32%
I am familiar with the Project Design	7	28%
I am familiar with the Share Function	20	80%
I am familiar with the Review Function	20	80%
I am familiar with the United Streaming Video Resources	8	32%
I am familiar with the Exhibit Center	10	40%
I use the Electronic Portfolio	22	88%
I use the Standards Stamper	7	28%
I use the Standards Library	8	32%
I use the Lesson Planner	7	28%
I use the Rubric Builder	11	44%
I use the Assessment Reporting Tools	8	32%
I use the Template Designation	6	32%
I use the Forms Function	7	28%
I use the Project Design	3	12%
I use the Share Function	16	64%
I use the Review Function	22	88%
I use the United Streaming Video Resources	2	8%
I use the Exhibit Center	5	20%

using the MAM model. The findings of this study are important because there is tremendous resistance to new technology in institutions of higher education around the world (Abduljalil & Zainuddin, 2015). University employees must stay competitive with modern technologies and resources. The SEM analyses provided support for all the three hypotheses. Perceived ease of use was a statistically significant predictor of the faculty's liking Live-Text and finding it useful. Live-Text users had higher scores on finding Live-Text useful, liking it, and finding it easier to use when compared to nonusers. Attitude toward Live-Text significantly predicted Live-Text usage based on date, semester, and duration. Perceived organizational support was a significant predictor of attitude toward Live-Text. Users of Live-Text had higher means for perceived usefulness and perceived ease of use than nonusers to a statistically significant degree. Most of the study participants widely utilized the electronic portfolio, review function, share function and rubric builders in Live-Text. The results of this study were consistent with previous studies that used motivational constructs with the TAM (Abduljalil & Zainuddin, 2015; Chen et al., 2013; Smith & Sivo, 2012).

The results of our study were different from a study conducted by Bousbahi and Alrazgan (2015) with regards to organizational support. Bousbahi and Alrazgan (2015) examined personal constructs such as motivation, load anxiety, and organizational support in the TAM to understand the reasons for faculty resistance to the adoption of a new Blackboard LMS in an institute of higher education. The authors found a significant relationship between organizational support, motivation, and perceived usefulness, because the faculty received e-learning organizational support from the dean to adopt Blackboard in the form of training and other support. The authors found an inverse relationship between the faculty's perceived usefulness and the actual use of Live-Text. In simpler terms, the more a faculty member used Live-Text, the less useful he/she found it. This finding points to numerous questions that the university should address because that might be the key to why some faculty resisted implementation of Live-Text. There may be challenges to the software such as difficult interfaces, slow response time, or other repairable issues that the university administration and IT could address. Another challenge may be the responsibilities associated with the software. The results indicate that organization was not a significant predictor for perceived and actual usage. The lack of organizational support should be thoroughly researched because a positive relationship with the organization and end user will provide a smoother implementation of Live Text than a demanding or draconian environment where software implementation becomes a forced responsibility. Perceptions of organizational support can change with proper positive motivators, such as rewards for early adopters and praise for using the system.

Implications for Research

This study has several research implications. A primary contribution is the combination of technology acceptance model and the CANE model of motivation to examine how faculty assess and accept an overall change in relation to the implementation of a new technology (Live-Text). By employing a dual perspective, the study contributes by operationalizing and testing the hybrid motivation acceptance model by assessing faculty's perception and attitude toward Live-Text itself and the organizational support that they expect to receive. Hence, theoretical insights for researchers that may assist faculty as well as students to utilize a new education-based IT application are provided. This study suggests that attitude, perceived ease of use, perceived usage, and perceived organizational support are important factors facilitating frequency of usage for university faculty members who are trying to adopt a new technology. This finding could be of use to future researchers who are trying to build a new technology acceptance and resistance model which could explicitly conceptualize and measure individual-level factors that increase or decrease user resistance. Attitude was a strong predictor for use of Live-Text. Further research into the early and positive adaptors may show patterns of use that can be shared with other users. If positive users have techniques or habits associated with the software, they can share these new techniques and provide a more positive environment for other users. Perceived ease of use was a predictor for how useful employees thought Live-Text was. Further research could determine why end users may perceive Live-Text as difficult or easy and provide information to address perceived facts and myths about its implementation.

A longitudinal analysis of how resistance and motivational constructs change over time would be worthwhile to study because the influence of these constructs may vary during the different phases of new technology implementation. Variables that have a positive or a negative influence on resistance (e.g., reactance, distrust, scrutiny, inertia, rewards, incentives) should also be analyzed in conjunction with motivational constructs in the TAM to understand the processes and conditions that lead to faculty resistance (Ngafesson, 2015) when adopting a new technology in the university. The hybrid MAM model can be applied to examine the influence of students' resistance and motivation when adopting a new technology. Furthermore, it would be useful to examine the mediating and moderating influence of resistance and other motivational constructs on faculty's behavioral intention, which, in turn, might influence usage behaviors. Abduljalil and Zainuddin (2015) conducted a similar study where a Chief Executive Officer's attitude mediated the relationship between his/her trust in adopting an accounting information system technology and their behavioral intention. All the factors mentioned can provide a positive environment for the implementation of Live-Text by customizing an instructor-led and web-based program with supporting publications. A solution to resistance to technology can be found by addressing the areas of concern through continued research and by applying the results to new solution initiatives.

Implications for Practice

This research can be the foundation for building training initiatives designed to support faculty in overcoming the true causes of resistance and enhancing their motivation through organizational support. The study provides suggestions for the university administration to alleviate faculty resistance to utilizing Live-Text. The study suggests that both technological and motivational factors simultaneously influence usage and acceptance of Live-Text. The university administration should demonstrate the advantages of Live-Text to the faculty by providing adequate resources to utilize the system. Higher administration should focus more on creating an environment that ensures that faculty members have a positive attitude and the requisite organizational support to utilize Live-Text. Furthermore, that Live-Text should be made more user-friendly is consistent with the current faculty needs, so that they will use it with ease and can develop a positive attitude toward the system. Faculty can be motivated to use a new technology such as Live-Text by engaging in well-constructed training programs with motivational, positive, and informed instructors. Some possible solutions may be increasing perceptions of how easy Live-Text is to use and increasing the positive support, commitment, and feedback from faculty in the implementation plus the administration and improvement of Live-Text. These may increase its acceptance and thus reduce resistance toward it.

Limitations

Limitations affected this study in certain aspects. First, the task value component of the CANE model was not incorporated in the MAM model, because Live-Text was a new technology that was introduced in the university. Faculty would only be able to better express their opinion on the importance, interest and utility of Live-Text after they have used it for some time. Second, the authors utilized convenient sampling. This study was an isolated observation of faculty members' opinions in one college at a single university with a specific population using one type of software. The results may or may not apply to other organizations, and this affects external validity. Additional research should take place on user resistance to new technologies. Third, the data was collected through self-report measures; therefore, social desirability bias might influence the results. Fourth, internal validity may have been hindered because there was faculty resistance to fill out the surveys due to active resistance (where they would directly say "no") and passive resistance (where they would give excuses such as "I don't have the time"). Respondents could have had biased or unresponsive opinions based on the structure of the survey. Incorporating qualitative research techniques such as case studies and anecdotal reporting could improve consistency in future studies.

Dr. Dan Siegel *is on the faculty at Full Sail University, Orlando, FL.*

Dr. Parul Acharya *is a Research Assistant Professor at Columbus State University, Columbus, GA.*

Dr. Stephen Sivo *is a Professor in the College of Education at the University of Central Florida, Orlando, FL.*

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School-wide and Classroom Policies on the Use of Mobile Technologies: An Exploratory Study

By Davison M. Mupinga

ABSTRACT

The presence of mobile technology devices in today's classroom cannot be denied, especially when a majority of students carry a device. Educators face the dilemma of choosing between embracing these mobile technologies or limiting their use in the classrooms. Mobile technology policies are in place to guide the use of the technologies at school. This study sought to establish school-wide and classroom policies on the use of mobile technologies, the practicality of enforcing these school policies, and the consequences for violating such policies. Data were collected using interviews from twenty-seven (27) in-service career and technical education high school teachers and school administrators. Almost all schools had a written policy on mobile technologies. The policies varied from specific to vague, and the majority of teachers believed the policies were difficult to enforce. Suggestions for crafting school policies on the use mobile technologies are provided.

Key words: mobile technologies, school policies, Bring Your Own Device (BYOD), classroom policies, cell phones

INTRODUCTION AND BACKGROUND

In today's world, mobile technologies have become an integral part of our daily lives and how organizations conduct business. For instance, about 95% of Americans own a cell phone of some kind and 77% own smartphones (Pew Research Center, 2017). Furthermore, according to the Pew Research Center (2012), about 67% of cell phone owners found themselves checking their phone for messages, alerts, or calls, even when their phones were not ringing or vibrating; and 44% of cell phone owners slept with their phone next to their bed because they did not want to miss any calls, text messages, or other updates during the night. In the workplace, about 94% of American small businesses use mobile technologies to conduct their business (ATT Newsroom, 2014). Even panhandling (street begging) has gone high tech these days – it is not uncommon to find panhandlers by road intersections carrying swipe machines (Houston, 2016), a clear sign of a tech-driven world. Although mobile technologies have been making inroads into education for decades (Vali, 2015), lately, through Bring Your Own Device (BYOD) or Bring Your Own Technology (BYOT) initiatives, a significant number of schools are incorporating mobile devices into classrooms (Herold, 2016). Mobile technologies, such as Netbooks, Notebooks, Tablets, Mobile Phones, iPads, and e-books have the advantage of bringing the outside world into the classroom by linking students to real people and giving them the capacity to work on real issues (Tomlinson, 2015).

Mobile technologies can be beneficial in a number of ways, for instance, when used to access Internet resources and digital tools that support teaching and learning (Kiger & Herro, 2015). The technologies increase opportunities for learning, particularly for students who find learning on a tablet more personal and easily accessible than being chained to a desktop (Vali, 2015). Furthermore, through mobile technologies, students can get real-time feedback from instructors, thereby making the learning process interactive and engaging (Schiola, 2015; Vali, 2015). Also, students are very familiar with these devices and commonly use them for their communication and informational needs (Cristol & Gimbert, 2014).

Through mobile technologies, a number of software applications (apps) can be made available to students and teachers in the classrooms. These apps can be downloaded free of charge or for a fee from iTunes, Google Play, or Amazon. The apps can assist teachers and students in a number of ways; for example, they can be used for sharing documents and files, storing files, managing class notes, keepin attendance, maintaining school records, and communicating with students and parents. According to Schiola (2015), apps "let teachers harness tech instead of fighting it." Examples of common apps used in the classroom include: Drop box, Google apps, eClicker Polling

Systems, Documents to Go, Wikipedia, Course Smart, Edmodo, Evernote, Twitter, iAnnotate, Pocket, ClassDojo, Class Messenger, Classroom Organizer, and Remind101 (Dunn, 2012; Schiola, 2015).

Similarly, mobile technologies have become a game changer in business. They have enabled companies to cut costs, and often allow employees to both work from and collaborate from anywhere (Higgens, 2013). However, in education, the adoption of mobile technologies has been very slow and uneven (Hennigan, 2014). The reluctance to adopt mobile technologies in education has primarily been attributed to a number of reasons, namely: (a) viewing mobile technology devices as a source for distraction in the classroom (Fisher & Frey, 2015); (b) limited and dwindling funding sources as well as older administrators and school board members oblivious to the potential of technology (Hennigan, 2014); (c) lack of time by the teachers to find out which apps are useful in the classroom (Schiola, 2015); (d) lack of equipment or infrastructure to support mobile technologies (Hennigan, 2014); (e) difficulty distinguishing between students' "own" work and work completed by mobile devices (Fisher & Frey, 2015); and (f) lack of adequate professional development for teachers who are required to integrate new technologies into their classrooms and yet they are unprepared or do not understand the new technologies (Nagel, 2013).

Individuals who regard the technologies as a source of distraction argue that students would not pay attention to learning tasks at hand, but instead, spend time on social media, listening to music, or playing online games. In support of this issue, one study on digital distractions in classrooms found that students spent an average of 20.9% of class time using a digital device for non-class purposes (McCoy, 2016). The mobile devices can be considered a distraction judging by the numerous times that individuals check for text messages or social media throughout the day. Many students and adults too, are attached to mobile devices and consider them "part of their lives" and, therefore, being separated from the gadgets may cause anxiety issues. According to Elmore (2014), nomophobia, derived from "no-mobile-phone phobia", is the anxiety that people get when they "lose their mobile phone, run out of battery or credit, or have no network coverage" (para 2). He adds, this phobia is considered worse among high school and college students, with some students taking showers with their mobile phones. Contrary to this seemingly negative view of mobile technologies in the classrooms, the technologies allow students to learn anytime and anywhere. Furthermore, it is important to note that when the devices are used within appropriate guidelines and with attention to instructional goals, they are powerful and cost-effective learning tools that can increase student engagement dramatically (Rogers, 2011).

Despite the numerous great apps available for educators' and students' use, a number of challenges have hampered full adoption of mobile technologies. Illustrating the challenges facing today's educators when it comes to mobile technologies in the classroom, Johnson (2015, para #6) asked:

Phones at school are inevitable. Should we embrace the "bring your own technology" (BYOT) model or the extreme "you take it out and I take it away!" policy? How do you monitor and keep 30 phones busy doing productive work? What do you do with the few kids that do not have phones? On the other hand, is keeping a phoneless classroom worth the hassle and effort of being the phone ogre? Can you have both?

A quick scan of school websites and research articles clearly shows how schools have responded to this challenge. Schools now have policies and practices that vary: some allow students full access to mobile devices and others have a complete ban on use of the technologies within school grounds. Some school policies reflect what goes on in business and social settings and embrace mobile technologies in the classrooms (Rogers, 2011). Unfortunately, other school policies are vague, silent, or outright prohibit the use of mobile technologies in school settings. This approach is perhaps due to fear of being labeled as unprogressive, avoiding liability issues or not knowing what direction to take on this issue. Either way, such policies and practices deprive teachers and students of the benefits of mobile devices in the classroom. Furthermore, the vague policies lead to confusion when it comes to how teachers and students treat mobile technologies within school grounds. This study sought to establish the school-wide and classroom policies on using mobile devices, with the intent of providing guidance to school districts as they formulate or revise policies on mobile devices.

STATEMENT OF THE PROBLEM

Considering the role mobile technologies play in social and business settings, today's education leaders are re-examining their policies and practices on the use of mobile technologies in school settings. However, the educators face a dilemma between embracing the technologies that have so much potential in the classroom and limiting the potential disruptions as well as controlling the behavior of users who seem inseparable from their gadgets. Should schools allow unrestricted access and use of mobile technologies? And, if so, will the schools be able to deal with unintended consequences from the unrestricted access? If not, are schools creating learning environments that are far removed from our day-to-day lives? There is need for realistic and fair school-wide and classroom policies on using mobile devices. Any realistic policies should consider the changing times, but at the same time, security issues, infrastructural limitations, and challenges with enforcement, as well as discrepancies among the students who either have or do not have the technologies should be acknowledged. Extensive searches on the web have revealed no standard policy or practice when it comes to mobile devices. In fact, in some schools, the policy statements are so vague that they are meaningless and impossible to enforce. This situation creates potential problems when it comes to practice in the real world. There is need to establish current school-wide and classroom policies and practices with the intent to guide school districts as they seek to embrace mobile technologies. Therefore, the purposes of this study were to: (a) establish the school-wide policies regarding the use of mobile technologies; (b) establish the challenges, if any, to enforce mobile device policies; and (c) determine penalties imposed by schools for violating mobile device policies.

METHOD

Data for this exploratory study were collected from high school career and technical education CTE teachers and school administrators using a survey and focus group interviews. Data were collected from a convenience sample – due to their convenient accessibility and proximity to the researcher. Twenty-seven (27) career and technical education high school teachers attending a professional development workshop at a Midwest university in the USA completed an online survey regarding school and classroom policies for mobile technologies. In addition, 27 school administrators responded to the survey. These school administrators were from the schools whose teachers responded to the survey. The CTE teachers and administrators participating in this study were from comprehensive schools, joint vocational centres, or in compact school districts.

The four survey questions on school-wide and classroom cell-phone policies were obtained from a survey by Obringer and Coffey (2007). Four open-ended questions pertaining to penalties for violating school-wide and classroom mobile device policies, common uses of mobile devices in the classrooms, concerns for adopting mobile technologies, and the support schools need to adopt mobile technologies were added to the survey. After completing the online surveys, each CTE teacher was asked to discuss his/her school-classroom mobile technology policy with an administrator to find out if there were any differences in understanding and implementation of the policies. Each CTE teacher wrote a summary of the conversation with his/her administrator on mobile device policies and these summaries were shared with other teachers in small group discussions during one of the professional development meetings. Three focus group interviews of nine CTE teachers per group were conducted to obtain additional information on uses of mobile devices to support teaching and learning and the support needed for schools to adopt mobile devices.

RESULTS

School Policies on Mobile Technologies

Almost all the high schools (96%) had some form of a written mobile devices policy. The policies on mobile technologies were posted on school websites, written in Student Handbooks, as well as in other school and classroom policy/rule documents. Three main policies governed the use of mobile devices in high schools, and these varied from complete freedom to use mobile technologies to restricted access or use of the devices on the school premises. With the exception of three schools, the other high schools had no mobile technology policy for teachers. There were three (3) main school-wide and classroom policies for mobile technology use for students: School Policy 1: The majority of the schools (66.6 %) did not allow the use of mobile technologies on school grounds. Most schools in this category prohibited students from having their cell phones with them or in the classroom; the mobile devices had to be kept in lockers until the end of the day. School Policy 2: A few schools (20.8%), allowed the use of mobile devices during certain times, such as before school starts, during lunches, and in hallways (when classes were not in session). School Policy 3: A small percentage of schools (16.7%) allowed the use of mobile devices in the classroom for instructional purposes. In this group, the teachers decided when students could use the mobile devices. Interestingly enough, many teachers felt that their school policies were outdated, not specific enough, and not easy to enforce. Table 1 shows policies on the use of mobile devices in classrooms.

TABLE 1: Policies on Usage of Mobile Devices in Classrooms

Mobile Device Policy	Frequency *N* = 27	Percentage
No mobile phone use during school hours. Students are not to be seen with a cell phone in hand and should keep them in their lockers at all times.	18	66.6%
Students can access their devices before the first bell, during lunch and in hallways. During class devices must be turned off or on silent mode.	5	20.8%
Students are free to use their mobile devices for educational purposes in the classroom setting.	4	16.7%

Inconsistencies were also observed from the school policies and current practices. At one high school, the mobile device policy stated that, “The use of cell phones during [the] school day is not permitted. Phones must be turned OFF from 7:50 a.m. until 3:30 p.m. (not on silent mode) and not visible, or they will be confiscated.” Howeve , the policy goes on to say, “cell phones may be used in class for educational purposes as directed by the classroom teacher.”

Some schools reported restricted access to school network from mobile devices. In addition, other schools did not allow students to bring their own mobile devices (BYOT) to school due to liability issues. Two reasons cited for blocking mobile devices from the school network were “not to overload the network” and “to prevent students from visiting inappropriate sites.” The problem of using the devices for cheating and bullying were other reasons to restrict mobile devices in school settings. By not supporting BYOT, schools were avoiding liability when the devices get lost, stolen, or damaged. Although at this particular school, there was a policy that the school was not responsible for lost, stolen, or damaged devices, it was understood that parents often want the school to help look for the lost devices. This situation, from one teacher’s point of view, would be a source of headaches. Therefore, it can be concluded that the school policies appear to be written to reduce liability issues rather than increase instructional opportunities.

Practicality of Enforcing Mobile Device Policies

Although all schools have written policies on mobile technologies, less than half of the teachers (44.5%) believed their policies were easy to enforce. At many of the high schools, students were allowed to keep their mobile devices with them throughout the day at school resulting in temptations to use them. To begin with, the students are accustomed to using their gadgets all the time and, therefore, enforcing a no-mobile technology policy may prove difficult. Another problem with enforcing the mobile technology policies stems from the ambiguity in some of the policies. As one teacher pointed out, “the lack of specific policies has given teachers and students both freedom and restraints.” At one high school, for instance, “Students are permitted to use mobile devices depending on the teachers. Some teachers allow the use of mobile devices in their classrooms … as long as they [students] follow school guidelines. Some [teachers] say not at all," reported one teacher. This lack of clarity on what is acceptable and when it is appropriate to use the mobile devices was said to cause a lot of confusion and anxiety among the students and teachers.

One interesting observation was the contradiction between some teachers' and administrators' understanding of their school policies for allowing students to use mobile devices while on school grounds. About sixty-six (66%) percent of the teachers felt their school policies did not allow the use of mobile technologies compared to seventy-two (72%) percent of administrators. Though small, the number of teachers and administrators who did not agree that their school policies did not allow cell phone usage is troubling. Considering that the teachers and administrators are supposed to be on the same page when it comes to what the policy says and how it will be enforced, such a situation means mixed interpretation of the school policies. The teachers who highlighted this discrepancy reported that it was their administrators who were not familiar with the school policy on mobile devices. Giving the administrators the benefit of the doubt on being unaware of their school policies on mobile devices, perhaps the discrepancy might have resulted from vague school policies that were open to different interpretations. This situation underscores the need for clear school policies. Therefore, whenever new school policies on using mobile devices are developed, there is the need to ensure that all stakeholders (administrators, school board members, teachers, parents, and students) are on the same page and understand the policy.

Consequences for Violating Mobile Device Policies

The consequences for violating mobile device policies seemed to be targeted at cell phones, and these varied according to the severity and frequency of the violations. Very few schools (22.2%) gave verbal or written warnings to students. In some schools (44.4%), the teachers and administrators confiscated the mobile devices. Another common consequence for violating mobile device policies was parental involvement. In about half of the schools, once a mobile device had been confiscated the schools notified the parents to come and pick up the device. The teachers reported that the devices were confiscated for di fering periods as short as one or two days or as long as the whole academic year. Only one school indicated keeping the mobile devices for the entire academic year. At the schools which confiscate the devices for a day or two, the common practice was that student were expected to collect the device at the end of the day or the parent was notified to come and pick it up from school before the end of the day. In-school detentions and suspensions from school or from the school network were also common penalties imposed when students continued to violate the mobile device policies. Table 2 shows the different consequences for violating mobile device policies.

Many school policies regarded the use of mobile devices as a privilege, and as such, students could lose the privileges if violations occurred. In one school district, the policy stated that,

> Discipline will be imposed on an escalating scale ranging from a warning to an expulsion based on the number of previous violations and/or the nature of or circumstances surrounding a particular violation … violations of the policy may be reported to law enforcement if the nature of violation warrants legal action.

Some examples of severe violations reported by the teachers included: cheating, hacking into

TABLE 2: Consequences for Violating Mobile Device Policies

Nature of Punishment	Frequency N = 27	Percentage
Notification of Parents	14	52.0%
Confiscation	12	44.4%
In-school Detention	10	37.0%
Suspension	8	29.6%
Verbal/Written warning	6	22.2%
Send to administrators	4	14.8%

the school network, and using mobile devices for criminal or inappropriate activities, such as bullying other students.

DISCUSSION

Although many high schools had mobile device policies in place, these appeared to be written to reduce liability issues rather than increase instructional opportunities. There were three main findings: (a) the majority of high schools restricted use of mobile devices on school grounds, (b) school-wide and classroom policies regarding mobile devices were not specific enough to allow easy enforcement by teachers, and (c) the consequences for violating mobile device polices, for a majority of the schools, seemed to indirectly punish the parents and add liability to the schools.

Restricted use of mobile devices on school grounds varied from school to school. The majority of schools did not allow use of the mobile devices at school, specifically in the classroom. Very few schools allowed unrestricted use of mobile devices by students, and the teachers decided when and how the mobile devices were used in the classrooms. A relatively small number of schools allowed use of devices outside the classroom, before the first bell and during lunches. At any other times, the devices were to be turned off or the students risked losing their phone privileges. Although mobile devices might be a source of distractions in the classroom, however, in this day and age, prohibiting the devices in school settings seems unrealistic and backward thinking. Some of the reasons include (a) this practice is not in sync with practices in social and work settings; (b) the mobile devices, especially mobile phones (e.g., smart phones), are now comparable to computers, they can bring the much needed outside world into the classroom, thereby enhancing 21st century skills (Tkach, 2016); (c) in the real world, today's students are expected to appropriately use these information and communication technologies to successfully function in a knowledge economy; and (d) these devices are an integral part of the students' lives and so, separating them from students causes anxiety.

Furthermore, with the push for authentic learning, that is, learning through applying knowledge in real-life contexts and situations, most of the educational practices do not match the talk. The classroom environments are far removed from the real world.

Today's world is abuzz with technology and yet, very little or limited technology exists in a majority of the classrooms. Even though there has been progress integrating technology into the classrooms, schools continue to deny students access to these tools. Students use mobile devices for most tasks a person can think of, yet often teachers still insist they not be used. This situation begs to question, at what point in their lives will the students learn how to appropriately use these tools? Prensky (2012) asked, "Should the Digital Native students learn the old ways, or should their Digital Immigrant instructors learn the new? Unfortunately, no matter if the [Digital] Immigrants may wish it, it is highly unlikely that the Digital Natives will go back" (p.71). Therefore, schools should embrace mobile device technologies and create learning activities that mirror what students do outside the classroom and in line with students' learning styles. On a positive note, the teachers and administrators who took part in this study recognized the value of mobile devices in the classrooms. They reported that their schools' current mobile device policies, specifically cell phone policies, which completely prohibited the use of the devices on school grounds were outdated and needed rewriting.

Another school practice that should be revised is blocking students and teachers from the school networks. One administrator argued that the reason for blocking students from school network was to "prevent students from visiting inappropriate sites." However, this may not be effective in preventing access to inappropriate websites, because students can still visit these sites using their phones. In any case, it is not about prohibiting the students from visiting the inappropriate sites: It is about teaching them how to safely surf the web and appropriately use mobile devices. The question becomes, If schools are not going to teach them proper Internet or cell phone etiquette, then who will?

School policies that are unclear, not practical, and those with consequences that do not deter violations can be challenging to enforce. Teachers expressed frustration that valuable teaching time was being spent on policing school policies on mobile devices. To complicate the issues, once devices were confiscated, the teachers were responsible for the security of the gadgets. Moreover, there is a concern that students can create a scene by refusing to surrender their mobile devices. One might ask, are schools prepared to deal with the repercussions from such school policies?

Therefore, it is advisable to seek input from all stakeholders: school board officials, school administrators, teachers, students, and parents on school policies regarding mobile devices.

School administrators and teachers should be aware of the role played by phones in the lives of today's students. These tools connect them with friends, virtual libraries, music and games, and more; they become in effect a personal assistant. According to an avid mobile device "junkie," T. Toasted (personal communication, January 20, 2017), when it comes to cell phones in the classrooms, teachers should realize that:

> My cell phone is metaphorically and physically connecting me to information and to other people. Therefore, it's possible for me to have an audience and a body of information (Google) that is not physically in the same location that I am. Teachers need to know who they are competing with [network of 300 friends or Google] for students' attention.

Schools cannot afford to completely remove these valuable tools from the classroom, because the technology enhances teaching and learning. As schools craft relevant policies, there is need to bring together all stakeholders (school board members, administrators, teachers, parents, and students). One starting point would be to consider other school's existing policies and continue the dialogue about their own school district.

Examples of schools that embrace mobile devices to enhance the teaching and learning include Benicia High School in California. This school acknowledges the value of mobile devices as outstanding instructional and learning tools and encourage both teachers and students to use them in the classroom (see Table 3). Posting such policies and consequences for violating the policies on school websites ensures that administrators, teachers, students, and parents are aware of the expected behaviors. For teachers

TABLE 3: Benicia High School's Electronics Policy / Cell Phone Policy

Cell phones/electronic devices may only be used for educational purposes in the classroom setting. If students wish to use their device for non¬-educational purposes, they may do so before the morning bell rings, during snack or lunch time, and after school: Monday through Friday.
Cell phones/electronic devices must be turned OFF before students enter any classroom, office, library, locker room, lab, and/or theatre. Students may power their phones at the request of the classroom teacher.
Once inside any of the aforementioned locations, students must store their cell phones/electronic device in a location that is not visible to the teacher or other students, even though the devices are OFF.
Students may use devices with teacher approval.
If cell phones/electronic devices ring, vibrate, or are used for any reason without teacher permission, or are visible anytime during class time or are used on campus during class time, a staff member may confiscate these devices.
Refusal to surrender your phone when asked is considered defiance. Defiance may result in disciplinary consequences, including suspension. Parents will be contacted.
First Offense: the devices will be held in the Administration office until the end of the school day and either a lunch or after school detention will be issued. Students may pick up their phone at the end of the school day.
Second Offense: the devices will remain in the main office until the end of the school day. An Administrator will assign a Saturday School, and establish parent contact. Phones may only be picked up by a parent.
Third Offense: the devices will remain in the main office until Friday. The Administrator will issue an in–house suspension and a Saturday School. Phones may only be picked up by a parent.
The staff of Benicia High requests your FULL co¬operation with our policy.
Source: Benicia Unified School District (2016)

and students, this adds another layer of clarity on what the school expects and when. Although many schools are eager to allow mobile devices in school environments, there is concern about not knowing what to do with disruptions from the devices. Therefore, mobile device etiquette is a skill that should be developed in today's students. Providing opportunities to use the mobile devices in the classrooms will likely help students realize that there are times when it is appropriate to connect and disconnect from the mobile devices. Denying access to the mobile devices does not teach students how to use the devices responsibly.

CONCLUSION AND RECOMMENDATIONS

The main findings of this study have implications to career and technical education programs. First, resources for CTE are not expanding proportionally to the increase in interest and demand for the programs (Gordon, 2014), and, therefore, allowing the use of mobile devices in CTE classrooms would provide access to the much-needed technology at very little or no cost to the schools or educational programs. Second, the use of a variety of interactive and hands-on activities is considered an effective strategy to engage and motivate students (Education Week Research Center, 2014). Therefore, if allowed in the classrooms, the currently underutilized mobile devices can be a valuable tool for engaging and motivating CTE students. For instance, a number of career and technical education teachers use applications such as Kahoot, Quiziz, Edmodo, Quizlet as well as a variety of tools from Khan Academy to engage and motivate students in the classrooms. Furthermore, the mobile devices can be useful when individualizing instruction for CTE students.

Third, mobile devices as instructional tools in CTE programs can be used to prepare students for the technologically rich workplaces. To ensure that CTE graduates can function in today's global work environment, they should be exposed to technologies used in the workplace. Therefore, any efforts by CTE programs to imitate real-world practices should be considered relevant and appropriate training.

Fourth, because many of today's students are obsessive phone users, there is the likelihood that completely prohibiting the use of mobile phones (total disconnection from their social peers) while at school may cause students to "completely lose their mind[s] when they are away from their phones," according to Addition Tips.Net (2015). This situation calls for allowing the use of mobile devices in the classroom, to ensure that the students become used to disconnecting when it is necessary to do so.

Overall, the school-wide and classroom policies reported in this study focused on unacceptable use rather than acceptable use as evidenced by the few policies encouraging use of mobile devices in the classrooms. As schools recognize the challenges and benefits of mobile technologies in the classroom, there is need to guide them in crafting policies that take into account the benefits of the technology, and ease of enforcement. By not crafting policies on the use of mobile devices, schools are not only inviting bad behavior from students, but they also may open the door to civil lawsuits and even criminal charges. Finally, a starting point would be establishing existing policies, identifying what is working and what is not, and adjusting or discarding policies as needed. In addition, there is need for the school administrators, teachers, parents, and students to come together to develop acceptable school policies. Furthermore, the policies should be posted on school websites, in Student Handbooks, or on classroom walls to ensure that all the stakeholders understand the crafted policy. And if they have not, all school districts need to provide professional development to administrators and teachers on how to use mobile devices to enhance teaching and learning.

Dr. Davison M. Mupinga *is an Associate Professor in career and technical teacher education at Kent State University. He is a member of the Mu Chapter of Epsilon Pi Tau.*

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Curriculum for an Introductory Computer Science Course: Identifying Recommendations from Academia and Industry

By Simon G. Sultana and Philip A. Reed

ABSTRACT

The purpose of this study was to define the course content for a university introductory computer science course based on regional needs. Delphi methodology was used to identify the competencies, programming languages, and assessments that academic and industry experts felt most important. Four rounds of surveys were conducted to rate the items in the straw models, to determine the entries deemed most important, and to understand their relative importance according to each group. The groups were then asked to rank the items in each category and attempt to reach consensus as determined by Kendall's coefficient of concordance. The academic experts reached consensus on a list of ranked competencies in the final round and showed a high degree of agreement on lists of ranked programming languages and assessments. The industry experts did not reach consensus and showed low agreement on their recommendations for competencies, programming languages, and assessments.

Keywords: Curriculum Design, Delphi, Competencies, Assessments, Computer Science Education, Programming Languages, Introductory Course

INTRODUCTION AND BACKGROUND

As education aims to prepare a workforce for future jobs, it is of little surprise that the number of students in introductory computer science (CS) courses have continued to grow in colleges and universities. These courses can cover information systems, hardware and architecture, operating systems, software engineering (SE), programming, databases, among other topics (Anderson, Ferro, & Hilton, 2011; Wu, Hsu, Lee, Wang, & Sun, 2014). Additionally, instructors can select from several computer languages (Ali & Smith, 2014; Chang, 2014; Shein, 2015) to provide students an experience that is educational, motivating, and meets current industry practices. Likewise, there are several possibilities for assessment in these courses (Fulton & Schweitzer, 2011; Muñoz, Martínez, Cárdenas, & Cepeda, 2013; Shaw, 2010). The aim of this research was to provide suggestions for the competencies, programming languages, and assessments for an introductory CS course. The class, part of a new undergraduate SE program at a small private nonprofit university in Fresno County, California, will serve as a program gateway for students looking to major or minor in SE, and for others looking to develop some background in computing.

Sources of CS Curriculum Recommendations

Expert recommendations on computing curricula are found in professional associations, industry, academic institutions, and the literature.
The Association for Computing Machinery (ACM) provided the first set of curriculum recommendations for undergraduate study in CS in 1965 and has published updates about once every decade, in recent years as part of the Joint Task Force on Computing Curricula (JTFCC, 2001; JTFCC, 2013). Though the JTFCC's recommendations have provided much value to institutions offering CS programs over the years, educators at liberal arts colleges and universities have often felt underserved by the documents (Liberal Arts Computer Science Consortium [LACS], 2007). The LACS last released a model curriculum almost ten years ago and based their suggestions on JTFCC's 2001 recommendations and included hours to focus on topics in introductory courses.

The computing industry includes businesses engaged in activities directly related to the disciplines of CS, computer engineering, information systems, information technology, and SE. Most of these distinct fields of study arose because of the individual skill sets required for these varied jobs and disciplines (Chand, 1974; Lunt, et al., 2005; Lutz, Naveda, & Vallino, 2014).

Industry defines the skills necessary for employment and education aims to teach them. Norton (1998) based the DACUM (Developing a Curriculum) methodology on the premise that experts in industry best define their jobs and possess certain knowledge, skills, and aptitude with tools. Business practices are developed to improve effectiveness and efficiency and there arises a need for new employees who possess some knowledge of, and perhaps the ability to implement, them. There has been much written over the past few years on the reasons for teaching agile software development practices in the classroom (Guercio & Sharif; 2012; Lutz et al., 2014; Rajlich, 2013). The computing industry has thus shown that it serves a role in the curriculum definition of CS and related disciplines.

There are approximately 1,300 academic institutions in the United States offering undergraduate programs in CS or related disciplines (U.S. News & World Report, 2015). Hambrusch, Libeskind-Hadas, and Aaron (2015) pointed to almost 800 such institutions in their study on the backgrounds of Ph.D. students majoring in CS Education and industry, therefore, can both be regarded as sources of expertise that can be useful for the development of new computing curriculum. The findings in the literature, along with experts' recommendations, serve as rich sources to help a curriculum designer choose competencies, programming languages, and assessments.

Competencies

There are myriad topics in the CS discipline (JTFCC, 2001) so a consideration of disparate areas was required if experts were to be provided with a comprehensive list. The JTFCC (2013) identified potential topics and the LACS (2007) provided recommendations on areas of study. Three introductory CS course textbooks were also consulted: these were *Connecting with Computer Science* (2nd edition) (2011) by Anderson, Ferro, and Hilton, *Invitation to Computer Science* (7th edition) (2016) by Schneider and Gersting, and *Computer Science Illuminated* (6th edition) (2016) by Dale and Lewis.

A literature review was conducted to supplement the topics identified in these texts. A straw model was developed using the information on competencies gathered from these sources. Although identification of potential competencies from curriculum recommendations/textbooks and journal articles was done independently, 24 of the 26 topics in the former sources were found in the latter group. In all, 38 competencies were identified to form the straw list introduced to the experts in this study.

Programming Languages

Introductory CS courses include programming to varying degrees (Davies, Polack-Wahl, & Anewalt, 2011). There are reportedly up to 2,500 programming languages (Kinnersley, n.d.), though not all are actively used. Regardless, there are numerous languages available to introduce students to computer programming. Of utmost importance is accessibility for non-majors and beginners (Kelleher & Pausch, 2005; Malan & Leitner, 2007; Norman & Adams, 2015; Stefik & Gellenbeck, 2011) and perceived importance by majors (Forte & Guzdial, 2005).

Six sources were consulted to determine language use in industry; these included the TIOBE index, RedMonk, the PopularitY of Programming Language (PYPL) list, Trendy Skills, Black Duck Software, and IEEE Spectrum. Four sources were found that identified language popularity in academia. O'Grady (2013) reported on RedMonk's (2015) use of references of programming languages in the curriculum of leading colleges and universities to rank the top twenty languages, as did three additional sources from journal articles, which included popularity rankings (Ben Arfa Rabai, Cohen, & Mili, 2015; Davies et al., 2011; Guo, 2014). Using the guideline to include languages that were identified in at least three of the six industry sources, or in at least two of the four academic sources, a list of twenty languages was constructed. Additionally, three visual programming languages were thought to warrant inclusion (Alice, Greenfoot, and Scratch) as they have become increasingly popular in introductory courses (Davies et al., 2011; Malan & Leitner, 2007). In all, 23 programming languages were identified to form the straw list introduced to the experts in this study.

Assessments

The literature contained articles in which educators teaching computing courses shared their curriculum designs and explained assessments. Many researchers mentioned assessments they utilized in the classroom as evidence of student learning to demonstrate results. The authors reviewed reported on some of the assessments used in introductory CS courses. Eleven distinct assessment devices were identified for academic and industry experts to consider for an introduction to a CS course. These items, in alphabetical order, were:

- Case studies
- Code reviews
- Concept questions
- Essays
- Final exams
- Interviews with professionals
- Lab exercises
- Online threaded discussions
- Quizzes
- Smaller programming activities
- Term projects

The goal of the study was to suggest competencies, programming languages, and assessments for an introductory CS course based on the recommendations of regional experts in academia and industry. This information could then be used by a curriculum developer to better meet the needs of students and other stakeholders in the region in which the introductory CS course was offered.

METHODS

The Delphi approach was used to collect data and surveys were distributed via SurveyMonkey. An email message with instructions and the appropriate link for each round was sent to the participants and they were asked to respond within one week. Follow-up emails were sent out during the week. This study's design was heavily based on the approach of Okoli and Pawlowski (2004) in that a panel structure was utilized, which divided the two expert groups as they selected items in Round 2 and ranked them in subsequent rounds. A major deviation from Okoli and Pawlowski's (2004) approach was to provide experts with straw models of initial items (Rotondi & Gustafson, 1996) for each of the three categories in Round 1.

Potential participants were identified using suggestions from professionals in higher education, graduates of academic programs, and research of organizations' web sites in California's Central Valley. All persons were invited to take part in the research by email. Phone calls were placed to those who did not initially respond. Snowball sampling was utilized to help increase exposure of the study to the expert population (Hays & Singh, 2012). Individuals who agreed to participate, therefore, were asked to suggest other candidates. The participants expressing interest were questioned about their backgrounds in the fields of computing and software development to verify they met the criterion of a minimum of five years' experience.

One research subject matter expert was also recruited for this study to assist the researcher in reviewing participants' open responses from the first round to validate their identification. This individual was required to have a Ph.D. and have experience teaching in an information technology related discipline.

In the first survey, each participant was asked to provide demographics (gender, age, current employment, years of experience, highest education earned in CS or a related field) and the number of programming languages in which the individual was fluent. The second set of questions asked the participants to rate the applicability of the competencies from the straw model on a five-point Likert-type scale (very important = 5, important = 4, moderately important = 3, of little importance = 2, unimportant = 1). The subsequent sections provided a list of programming languages and assessments. Blank entries were also available for optional contributions to each of the three categories.

The results of the surveys were downloaded into Microsoft Excel. Statistics were computed for the age, years of experience, number of programming languages in which the participants were fluent, gender, employment, and highest education were computed using various built-in functions. Responses to each of the three content categories were also copied into Excel and quantified according to the anchors as previously identified. Newly suggested items by participants were checked for individuality and inserted into the lists. The newly suggested items were reviewed with the subject matter expert and changes to the surveys for the next round were made. Any item selected by at least two participants was added to the list of competencies, programming languages, or assessments.

The rated lists of items and their median weight scores were added to the survey for the second round. The median was computed as these data were Likert-type in nature (Boone, H. N. Jr. & Boone, D. A., 2012) and this value in the questionnaires would communicate the perceived importance attributed to each item. The participants were instructed to determine whether each of the items should be included for the introductory CS course by choosing to select at least ten topics for each of the three categories (Okoli & Pawlowski, 2004). The items were imported into SurveyMonkey as two equivalent questionnaires for the academic and industry groups.

At this stage, the study took on a panel structure (Okoli & Pawlowski, 2004). The industry and academic groups were given separate links so analysis of their feedback could be done independently. This design would potentially allow experts to come to consensus more quickly and would allow recommendations from each group to be distinguished for final decision making by the curriculum designer/researcher.

Feedback was collected from participants on their selected items from each of the three categories. Those items selected by at least half of each expert group were chosen to be included for Round 3 (Okoli & Pawlowski, 2004) for that group. The findings from this point would be independent for each group.

The steps in Rounds 3 and 4 were identical. The lists of items as selected by the experts from the previous round were added to the survey. Participants were asked to rank each item in each of the three categories of competencies, programming languages, and assessments. The lists were imported into SurveyMonkey as two questionnaires in keeping with separate panels.

The coefficient of concordance, Kendall's W, was used to determine the level of agreement among the participants' ranked lists for each panel. Kendall's W ranges from zero to one to indicate a scale of increasing unanimity between rankings (Field, 2009). Schmidt (1997) identified a value of at least 0.7 to indicate strong agreement so this threshold was used to determine whether any of the lists of competencies, programming languages, or assessments needed to be submitted in a fourth round to either of the panels. The W value would, therefore be computed six times for Round 3. Each W value would be analyzed independently and only those topics that failed to meet the minimum 0.7 threshold value were included in a Round 4 survey for each individual panel.

It was decided that a maximum of four rounds would be considered as it has been found that major fluctuations are typically not expected after a fourth round (Wilhelm, 2001) and participant fatigue can become a concern (Schmidt, 1997; Sitlington, 2015). Two ranked lists of suggested competencies, programming languages, and assessments were available as the industry and academia experts would likely have different preferences. These data would then be used in the curriculum development of the introductory class to the extent desired by the course designer. See Figure 1 for an overview of the study's design methodology.

Participants

The target members for experts were experienced industry and academic professionals in California's Central Valley. Since the opinion of experts in these positions was sought, a minimum of five years' experience was required for potential industry participants (Guu, Lin, & Lee, 2014; Joyner & Smith, 2015). Educators who held at least a Master's Degree in their field (Surakka, 2007) were approached about their interest in participating as academic experts. The researcher directly invited 85 experts from California's Central Valley; 48 individuals (56%) were from higher education; and 37 (44%) were from industry. A total of 23 individuals (27% of those directly invited) agreed to participate in the study. There were 11 persons (48%) in the industry group and 12 persons (52%) in the academic group.

RESULTS

Round 1

Eleven academic (92%) and eleven industry (100%) experts completed the Round 1 survey, including twenty males and 2 females (one from academia and one from industry). The second section of the survey asked participants to rate potential competencies for an introductory CS course. It was noteworthy that four competencies, those dealing with procedural programming, teamwork/interpersonal group skills, problem solving, and critical thinking, received median scores of 5 (very important) and the latter three items received minimum rating values no lower than 3.

The next section of the survey asked participants to rate programming languages in terms of their importance for an introductory CS course. The rating scale was similar to the one used for course competencies with the inclusion of an option titled "unfamiliar," which was weighted

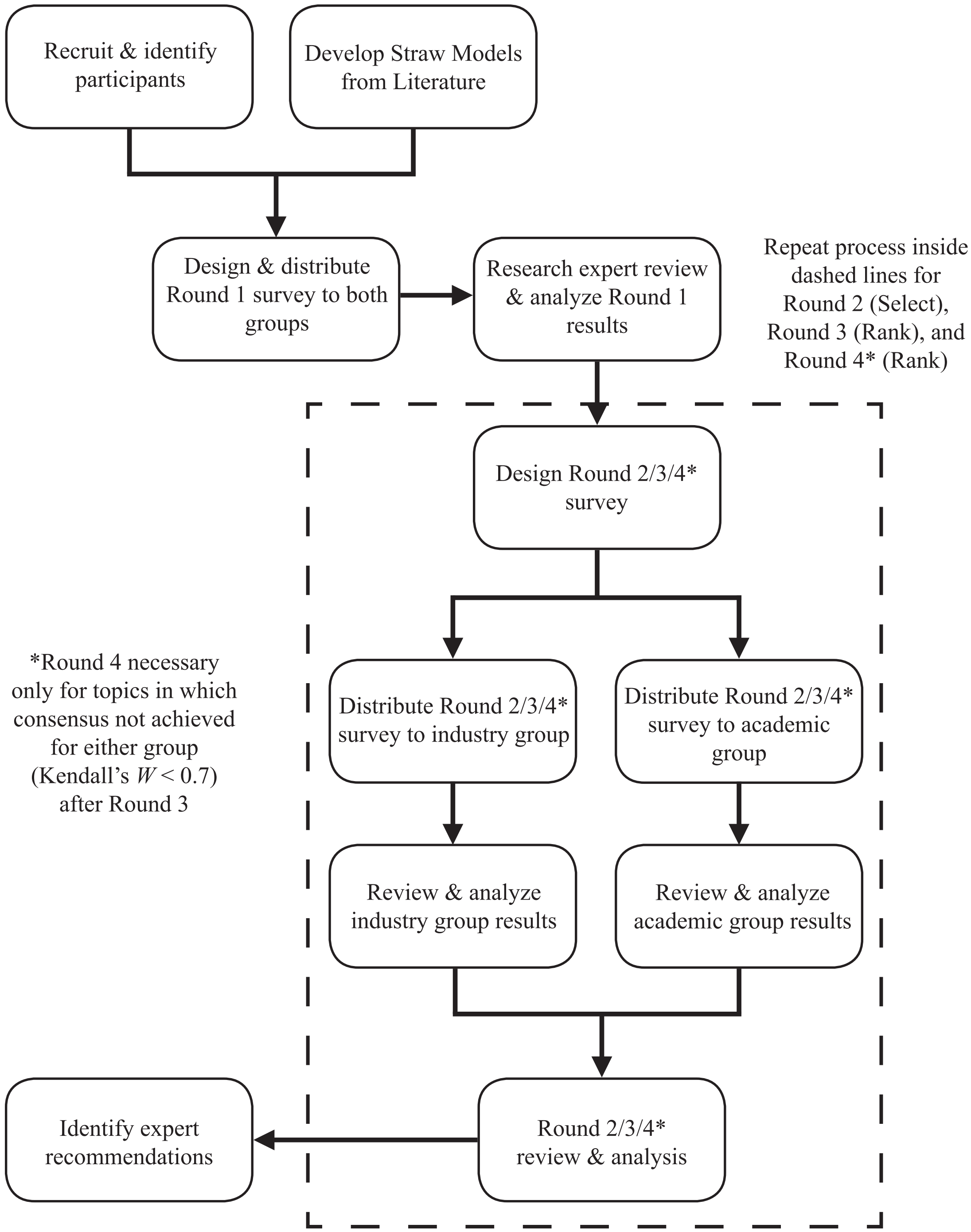

Figure 1. Study design methodology

as 0 points. Only 5 of the 23 languages were known to all the participants, including assembly language, C, C++, Java, and Visual Basic. Six languages achieved median scores of zero, indicating unfamiliarity by more than half the group (Alice, Greenfoot, Haskell, R, Scheme, and Scratch). Five languages were rated as being "very important" according to their median rankings (C#, C++, Java, JavaScript, and Python). The experts provided six open-ended responses to the optional questions about additional programming languages not listed but only HTML5 (Hypertext Markup Language) was mentioned in two responses. Though not typically considered a true programming language, HTML5 was added to the list for Round 2 because concepts in CS could be taught using this markup language.

The final section of the Round 1 survey asked participants to rate 11 potential assessments. The rating scores available were identical to those used with the course competencies. The experts provided only four open-ended responses to the list of assessments to be considered. Team programming assignments were recommended by two individuals so this assessment was added for Round 2.

Round 2

The median ratings of the competencies, programming languages, and assessments were recorded into the survey for Round 2 to communicate the importance attributed to each item by the overall group. The goal of the second round was to give experts the opportunity to narrow down the lists they would rank in Rounds 3 and 4 (Okoli & Pawlowski, 2004). Participants were instructed to select no fewer than 10 items from each of the lists of competencies, programming languages, and assessments. They were also advised to consider their opinions on each item in relation to the importance attributed by the overall group as indicated by the median rating score from Round 1. This instruction enabled participants to utilize deliberation as characterized by the Delphi approach without meeting with other experts in person.

Eight programming languages were selected by at least half of the experts in the academic group. The industry group elected to include 12 languages. All eight languages selected by at least half the experts in the academic group were also chosen by the industry group. The sole programming language chosen by all industry experts was JavaScript. No academic expert chose Greenfoot and no industry professional included Alice, Greenfoot, MATLAB, Scala, or Scratch.

Finally, the groups ranked 11 assessments. Because of the low number of assessments, the narrowing effect was expected to be minimal. Only essays were not chosen to be carried over into Rounds 3 and 4 and this omission was true for both groups.

The detailed data from Rounds 1 and 2 are not included in this article but are available in Sultana (2016).

Round 3

The third round provided experts the opportunity to rank the items selected in the previous round. The participants were instructed to rank the items in each of the lists according to their importance for an introductory CS course for majors and non-majors. They were again advised to consider their opinions on each entry in relation to the importance attributed by the overall group as indicated by the number of experts in their group selecting it in Round 2. There were 19 total experts who participated in the third round with 10 in the industry group (91%) and nine in the academic group (75%).

The academic group ranked 15 competencies and the industry experts ranked 12 competencies as shown in Table 1. The interquartile range (IQR) was calculated to identify the dispersion of the middle half of these data. The IQR values for the rankings of the top five competencies varied from 3.0 to 5.5 for the academic group and from 5.3 to 7.5 for the industry group.

The ranked programming languages from Round 3 for both groups are presented in Table 2. The academic group ranked eight programming languages and chose Java as their most important and C++ as the next highest ranked. The industry experts ranked 12 languages and selected JavaScript and Python as their most important.

Finally, the groups ranked 11 assessments. Both groups selected smaller programming activities among their highest ranked items and did so with little variability as indicated by the low IQR values of 1.5 for the academic group and 2.3 for the industry group. The academic experts also selected lab exercises as a top assessment and again did so with a low variability (IQR = 2.0). The industry group also selected term projects as tied for the most important assessments but with a high IQR value (8.3).

Kendall's *W* was calculated to analyze the conformity among the rankings of the three categories by the expert groups. Linear transformations of the Kendall's *W* were performed to describe the corresponding correlations (r) so the level of agreement for each of the categories by the groups could be identified (Zaiontz, 2013). *P*-values were calculated to determine significance. Neither group reached the consensus threshold of $W = 0.7$, as recommended by Schmidt (1997), on any of the three categories in Round 3.

Even so, the academic experts apparently agreed more on each of the three categories than did the industry experts. Kendall's coefficient of concordance (*W*) tests were statistically significant, yet lacked full agreement, for the academic group on the competencies ($W_{AC} = 0.57$, $r_{AC} = 0.52$, $p < 0.001$), programming languages ($W_{AL} = 0.63$, $r_{AL} = 0.58$, $p < 0.001$), and assessments ($W_{AA} = 0.53$, $r_{AA} = 0.48$, $p < 0.001$).

TABLE 1: Rounds 3 & 4 Median Rankings of Competencies for Introductory Computer Science

Competency	Round 3				Round 4			
	Academic Group		Industry Group		Academic Group		Industry Group	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Analyze algorithms for effectiveness and efficiency	9.0	4.0	7.0	5.3	9.0	2.0	7.0	3.0
Describe different types of data representation	-	-	7.0	5.5	-	-	7.0	4.0
Describe basic computer architecture and organization	12.0	5.5	6.5	9.0	11.0	3.0	6.0	7.0
Illustrate the use of databases and apply SQL	-	-	9.5	4.5	-	-	11.0	2.0
Explain the functionality of operating systems with examples	12.0	4.5	-	-	13.0	2.5	-	-
Describe common programming languages and popular uses	-	-	7.5	6.3	-	-	9.0	7.0
Demonstrate use of recursion in a program	12.0	3.0	-	-	13.0	2.0	-	-
Describe best practices for computer and data security	14.0	2.0	-	-	15.0	2.5	-	-
Explain the role of modeling and simulation in computing	12.0	6.5	-	-	14.0	1.5	-	-
Describe process and practices in SE	11.0	4.5	5.0	6.0	10.0	1.0	3.0	5.0
Write functioning object-oriented programs	3.0	4.5	7.0	3.8	2.0	0.5	9.0	5.0
Write functioning procedural programs	1.0	4.5	5.5	5.3	1.0	1.0	6.0	5.0
Implement good documentation practices in programming	7.0	7.5	8.5	7.3	7.0	2.5	8.0	5.0
Demonstrate teamwork and interpersonal group skills	8.0	6.5	6.0	7.5	8.0	2.5	6.0	3.0
Demonstrate algorithmic thinking	5.0	5.5	-	-	4.0	4.0	-	-
Demonstrate computational thinking	6.0	3.0	-	-	6.0	0.5	-	-
Demonstrate problem solving	3.0	3.5	2.5	7.5	3.0	1.0	2.0	2.0
Demonstrate critical thinking and reasoning	5.0	3.0	3.0	7.3	5.0	2.0	2.0	5.0

Note. $N = 9$ for academic group and $N = 10$ for industry group in Round 3, and $N = 9$ for academic group and $N = 11$ for industry group in Round 4.

TABLE 2: Round 3 & 4 Median Rankings of Programming Languages for Introductory Computer Science

Programming Language	Round 3				Round 4			
	Academic Group		Industry Group		Academic Group		Industry Group	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Assembly Language	-	-	10.0	4.3	-	-	11.0	9.0
C	4.0	2.5	7.0	4.8	4.0	4.0	7.0	5.0
C#	6.0	2.5	4.5	5.8	8.0	3.0	4.0	3.0
C++	2.0	2.0	5.5	4.0	2.0	1.5	6.0	4.0
HTML5	-	-	5.5	5.8	-	-	6.0	4.0
Java	1.0	1.5	4.5	6.8	1.0	2.0	3.0	7.0
JavaScript	7.0	3.5	3.0	2.3	6.0	3.5	3.0	4.0
PHP	6.0	2.5	6.0	7.3	6.0	2.0	9.0	5.0
PL/SQL	-	-	8.0	4.3	-	-	8.0	4.0
Python	4.0	2.5	3.0	5.3	4.0	1.0	3.0	4.0
Ruby	6.0	2.0	9.5	3.3	6.0	1.0	9.0	6.0
Shell	-	-	9.0	4.8	-	-	8.0	3.0

Note. *N* = 9 for academic group and *N* = 10 for industry group in Round 3 and *N* = 9 for academic group and *N* = 11 for industry group in Round 4.

The industry experts also fell short of the agreement threshold in their rankings but achieved statistical significance in their rankings for assessments ($W_{IA} = 0.20$, $r_{IA} = 0.11$, $p = 0.03$). Their agreement levels for the competencies ($W_{IC} = 0.13$, $r_{IC} = 0.03$, $p = 0.21$) and languages ($W_{IL} = 0.10$, $r_{IL} = 0.00$, $p = 0.43$), however, lacked statistical significance.

Round 4

Because of the lack of consensus among either group on any of the three categories, the Round 3 surveys were reproduced for Round 4. The coefficient of concordance values for each category were included and explained in the subsequent survey so the participants would have information on the level of consensus they had achieved. The median rank values were also provided so the experts could weigh their preferences against those of the rest of the group. There were 20 experts who participated in the final round. All eleven industry members participated (100%) and nine of the twelve academic experts (75%) completed surveys. Round 4 rankings for competencies by both groups are presented in Table 1. The academic group made only slight changes to their rankings for competencies from Round 3. The situation was similar for the industry group's rankings, though to a reduced extent. Most items experienced a decrease in IQR, again pointing to less variation in competency rankings.

The Round 4 results for programming languages are shown in Table 2. The academic group changed little in their rankings from Round 3 to Round 4. Java remained the top language, (median rank = 1.0, IQR = 2.0), followed by C++ (median rank = 2.0, IQR = 1.5). The industry group had a few more noteworthy changes in their rankings of programming languages. Java (median rank = 3.0, IQR = 2.0), joined Python (median rank = 3.0, IQR = 1.0) and JavaScript (median rank = 3.0, IQR = 4.0) as the most important languages. Assembly language held its position as last (median rank = 11.0) but experienced a sizable increase in variability (IQR = 9.0) among its rankings.

The final round rankings for assessments by each group are shown in Table 3. Again, the academic group exhibited little difference in their ranked lists. Lab exercises were deemed the most important assessment by the group (median rank = 1.0, IQR = 1.5), followed by smaller programming activities (median rank = 2.0, IQR = 1.0). The industry group ranked assessments slightly differently than they had in Round 3. Smaller programming activities (median rank = 1.0, IQR = 4.0) was still chosen as the most important assessment device, though on its own in Round 4.

Table 3: Rounds 3 & 4 Median Rankings of Assessments for Introductory Computer Science

Assessment	Round 3				Round 4			
	Academic Group		Industry Group		Academic Group		Industry Group	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
Case Studies	9.0	4.5	6.5	2.3	8.0	2.5	7.0	1.0
Code Reviews	6.0	3.0	4.5	2.0	6.0	3.0	5.0	4.0
Concept Questions	5.0	2.5	6.0	5.8	4.0	3.5	5.0	3.0
Final Exams	7.0	3.0	8.0	3.0	8.0	3.5	9.0	3.0
Threaded Discussions	10.0	1.5	9.0	4.3	10.0	1.0	11.0	3.0
Interviews with Professionals	10.0	1.5	8.5	4.0	11.0	3.0	9.0	4.0
Lab Exercises	2.0	2.0	4.0	6.8	1.0	1.5	3.0	2.0
Quizzes	6.0	3.5	8.5	7.5	6.0	2.5	8.0	8.0
Small Program Activities	2.0	1.5	3.0	2.3	2.0	1.0	1.0	4.0
Team Program Assignments	4.0	3.5	6.0	5.5	3.0	2.5	6.0	4.0
Term Projects	6.0	4.5	3.0	8.3	6.0	3.0	4.0	5.0

Note. $N = 9$ for academic group and $N = 10$ for industry group for Round 3 and $N = 9$ for academic group, and $N = 11$ for industry group for Round 4.

Kendall's coefficient of concordance (W) tests were again conducted. Consensus was only achieved by the academic group on the rankings for competencies ($W_{AC} = 0.84$, $r_{AC} = 0.82$, $p < 0.001$). Though concordance values increased for both groups on each of the three categories, the academic experts again showed higher conformity than those from industry. Kendall's W values again showed statistically significant ranked lists by the academic group on the competencies, programming languages ($W_{AL} = 0.63$, $r_{AL} = 0.58$, $p < 0.001$), and assessments ($W_{AA} = 0.67$, $r_{AA} = 0.62$, $p < 0.001$). The concordance values for the industry group again revealed less conformity in their rankings but this time achieved statistical significance in their lists for both competencies ($W_{IC} = 0.32$, $r_{IC} = 0.25$, $p < 0.001$) and assessments ($W_{IA} = 0.37$, $r_{IA} = 0.31$, $p < 0.001$). The industry group, however, displayed little agreement on programming languages and the lists lacked statistical significance ($W_{IL} = 0.12$, $r_{IL} = 0.02$, $p = 0.25$).

CONCLUSIONS

The overall goal of this study was to identify regional experts' recommendations to help better design an introductory CS course for majors and non-majors. Professionals in academia and industry can provide invaluable input on the content, and though their interests are varied, there can be similarity on recommended course components such as competencies, programming languages, and assessments. See Table 4 for a list of the competencies and Table 5 for the assessments suggested by the experts in this study.

The experts recommended a CS course that provides students with a focus on programming and SE process along with training in professional soft skills, such as problem solving, critical thinking, and teamwork. These same attributes were identified by the National Association of Colleges and Employers (2016) as being most important for career readiness. Those designing curriculum for CS and related fields should focus on helping students to develop these abilities. These experts also recommended that assessments be based on the opportunity to learn by doing; in the form of smaller and team programming activities, lab exercises, term projects, and more traditional concept questions. Code reviews should also be used to help students learn best practices and build their own knowledge. These types of assessments are very much in line with the recommendations of Crawley, Malmqvist, Östlund, Brodeur, and Edström (2014). Interestingly, the assessments recommended by these experts seemingly point more to an introductory course in SE, other than one in CS.

Table 4: Top Recommended Competencies for Introductory Computer Science by Both Groups (Unranked)

Competency
Demonstrate problem solving
Demonstrate critical thinking and reasoning
Write functioning procedural programs employing programming fundamentals
Describe process and practices in Software Engineering
Demonstrate teamwork and interpersonal group skills
Write functioning object-oriented programs employing programming fundamentals
Implement good documentation practices in programming
Analyze algorithms for effectiveness and efficiency
Describe basic computer architecture and organization

The choice of programming languages to use in introductory CS courses will likely remain a contentious one. A curriculum designer is well advised to use a language like Java, which continues to thrive in the classroom and in industry. It is important, however, to consider the audience and keep a close eye on the dynamic programming field. Python continues to increase in popularity and its accessibility and versatility make it a strong choice, especially for courses with non-majors (Enbody, Punch, & McCullen, 2009). Though visual programming languages like Alice, Greenfoot, and Scratch were not known to many of the participants in this study, an increasing number of experts in the literature recommend they should continue to be considered to introduce concepts in programming before transitioning to a language like Java or Python (Daly, 2011; JTFCC, 2013; Malan & Leitner, 2007).

TABLE 5: Top Recommended Assessments for Introductory Computer Science by Both Groups (Unranked)

Assessment
Smaller programming assignments
Lab exercises
Concept questions
Term projects
Code reviews
Team programming assignments

A suggestion for additional research would be to include focus groups or one-on-one interviews with academic and industry professionals. The online Delphi approach used in this study was successful in that 20 academic and industry professionals remained engaged through four rounds and provided valuable information. Alternate designs, however, would allow for the study of the differences between the groups. Separate interviews would help to identify the reasons for experts' choices and help the curriculum designer make more informed decisions. Finally, most academic programs have industry advisory groups that are excellent resources to provide this level of detail and for recommendations aimed at continuous improvement.

Simon G. Sultana*, Ph.D. is an Associate Professor in the Department of Computer Science and Mathematics at Fresno Pacific University, California.*

Philip A. Reed, Ph.D. *is a Professor in the Department of STEM Education and Professional Studies at Old Dominion University, Norfolk, VA, and is a member of the Beta Chi Chapter of Epsilon Pi Tau.*

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