Volume XL
Number 1, Spring 2014
Number 2, Fall 2014

The Journal of Technology Studies

Promoting Excellence in Preparation and Excellence in Practice

From the Three R's to STEM

Today's Teachers and Classrooms are Going High Tech

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

The Journal of Technology Studies(JTS) (ISSN 1071-6048) is the flagship, peer-reviewed journal of Epsilon Pi Tau, Inc., a nonprofit, academic and professional honor society. Headquarters and editorial offices are located at the Technology Building, Bowling Green State University, Bowling Green, OH 43403-0296. Use this address or jots@bgsu.edu for subscription matters or purchases.

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Two print issues per year are mailed to all members of the society upon request and to academic and general libraries around the globe. Issues that are published online only, the aforementioned printed issues, and past issues are available online at scholar.lib.vt.edu/ejournals/JTS.

The journal is currently indexed in Current Index to Journals of Education (USA),International Bibliography of the Social Sciences (IBSS) (UK), and the International Vocational Education and Training and Research Database at http://www.ncver.edu.au (Australia).

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Printed in the United States of America by Post Printing Company, Minster, Ohio.

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Volume XL, Number 1, Spring 2014

Technology Skill Development Among Education Majors

By Chad Sherman

ABSTRACT

This study sought to determine the influence that numerous variables have on the technology skill development of education majors. The study investigated how the participants' age, gender, race, ethnicity, level of comfort with technology, and learning style(s) correlated with their level of digital literacy. The results revealed that level of verbal-linguistic intelligence significantly correlated with the subjects' level of digital literacy, whereas the other seven multiple intelligence variables did not yield significant findings. Further statistical analysis demonstrated that each of the multiple intelligence variables (including level of verbal-linguistic intelligence) had a weak correlation with level of digital literacy when isolated from the other variables. Each one of the independent variables was found to be a poor predictor of the education majors' technology capabilities. Therefore, this article suggests that these variables (age, gender, level of prior technology use, etc.) should not be relied upon to predict a student's technology skills.

Key words: Digital literacy, Multiple intelligences, Educational technology, Learning styles

INTRODUCTION

This study sought to determine the influence that numerous variables had on the development of technology skills in education majors. According to some studies, college students display high levels of use of and comfort with computers and other digital tools (Smith, Salaway, & Caruso, 2009). Several scholars have tried to determine which variables most affect an individual's digital skills, but their findings have been inconclusive. Specifically, education majors are a substantial focus for analysis, because of the importance that has been placed on their digital competency (Banister & Vannatta, 2006). It has also been proposed that the digital skills of education majors are not sufficient for today's world.

PROBLEM STATEMENT

Banister and Vannatta (2006) acknowledged that many teacher candidates have deficiencies in their digital technology skills that should be addressed. Additionally, research is inconclusive about which demographics affect digital literacy (Barbour & Cooze, 2004; Dednam, 2009; Eshet, 2002; Eshet-Alkalai & Amichai-Hamburger, 2004; Eshet-Alkalai & Chajut, 2009; Hargittai, 2002; Hargittai, 2010; Smith et al., 2009). The literature, however, suggests that a student's learning style may correlate with that person's digital literacy. Several theorists have speculated that coordinating learning technologies with a student's learning style can provide a stronger educational experience (Gen, 2000; McCoog, 2007). Empirical evidence also suggests that there is a connection between a student's learning style and achievement in a technology-laden course (Barbour & Cooze, 2004.

Research Questions

The following research questions were developed:

- Does a pre-service education major's verbal-linguistic intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's visual-spatial intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's logical-mathematical intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's musical-rhythmic intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's bodily-kin-esthetic intelligence significantly affect his or her score on a digital literacy assessment?

- Does a pre-service education major's interpersonal intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's intra-personal intelligence significantly affect his or her score on a digital literacy assessment?
- Does a pre-service education major's naturalistic intelligence significantly affect his or her score on a digital literacy assessment?
- To what degree does the interplay between the eight multiple intelligence learning styles predict pre-service education majors' level of digital literacy?

Hypotheses

The alpha level for this study is *p* = .05. The following hypotheses were developed:

- A pre-service education major's verbal-linguistic intelligence positively affects his or her score on a digital literacy assessment.
- A pre-service education major's visual-spatial intelligence positively affects his or her score on a digital literacy assessment.
- A pre-service education major's logical-mathematical intelligence positively affects his or her score on a digital literacy assessment.
- A pre-service education major's musical intelligence does not significantly affect his or her score on a digital literacy assessment.
- A pre-service education major's bodily-kinesthetic intelligence does not significantly affect his or her score on a digital literacy assessment.
- A pre-service education major's interpersonal intelligence does not significantly affect his or her score on a digital literacy assessment.
- A pre-service education major's intra-personal intelligence does not significantly affect his or her score on a digital literacy assessment.
- A pre-service education major's naturalistic intelligence does not significantly affect his or her score on a digital literacy assessment.
- The eight multiple intelligence learning styles predict pre-service education majors' level of digital literacy.

Review of the Literature

Gardner's theory of multiple intelligences (1983) offered an improved method to describe intelligence and put a focus on individualized education. The theory was developed to focus on how a student prefers to learn--an approach not commonly seen in education until recent decades (Gardner, 2003; Teele, 2000).

Gardner theorized that each student has a unique set of intelligences to which they adapt their learning processes. Each student learns in an individual manner (Gardner, 1993a, 1999, 2003; Teele, 2000). Varying types of instruction are required to stimulate and encourage students to utilize their own unique learning styles. Gardner's theories have been applied mostly to educational psychology, but they also can be applied to digital literacy (Barbour & Cooze, 2004; Gen, 2000; McCoog, 2007; McCoog, 2010) and to education (Campbell, 1990). Gardner (1993b) also theorized that multiple intelligence theory could be combined with digital literacy. He argued that computers can be utilized to match individuals to a mode of instruction that is best suited to their intelligence. Gardner (1995) added that this combination forms the foundation for a great education. Other scholars have argued that digital technology can be used to great such a foundation (Gen, 2000; Grant, 1999; Leu, Leu, & Len, 1997; McCoog, 2007; Silver, Strong, & Perini, 2000).

Limited Effects of Several Demographics

Several demographics may correlate with an individual's digital literacy abilities. However, the literature in this area is inconclusive at best. Because the literature concentrates heavily on these demographics, they will be briefly discussed.

Age

Eshet's (2002) qualitative study suggested that a relationship exists between age and digital literacy. Eshet-Alkalai and Amichai-Hamburger (2004) found that adults scored significantly lower than other age groups. Eshet-Alkalai and Chajut (2009) conducted a follow-up study and found similar results.

Other researchers have identified mitigating factors. For example, Hargittai (2002) argued that such findings were likely due to their varied levels of comfort with technology. Likewise, van Deursen and van Dijk (2008) similarly suggested that extraneous variables likely were more accountable for variations in digital literacy than age. Other researchers have failed entirely to find a correlation between age and digital literacy (Hargittai, 2012; Koroghlanian & Brinkerhoff, 2008).

Gender

Shashaani (1997) identified significant differences between the attitudes of males and females regarding computers. However, the study specifies that previous experience is likely the source of the difference. Similarly, Comber, Colley, Hargreaves, and Dorn (1997) proposed that males have more confidence when using computers. When previous was controlled for, the researchers found no statistically significant differences.

It has been suggested that men and women also differ in their usage of specific computer technologies. Men are more intensive Internet users than women (Bimber, 2000) and use the Internet more frequently (Jones, Johnson-Yale, Millermaier, & Pérez, 2009). Others (Jackson, Yong, Kolenic, Fitzgerald, Harold, & Von Eye, 2008) have suggested that men and women significantly differ in the intensity and nature of their technology use.

Gender also may predict how an individual applies technology to his or her life. Van Braak, Tondeur, and Valcke (2004) found that male teachers integrate computers into their classrooms more often. Karsten and Schmidt (2008) discovered that female business students scored significantly lower on a measure of computer self-efficacy. Koroghlanian and Brinkerhoff (2008) found significant differences indicating that males have higher digital literacy than do females. Males also scored significantly higher on an assessment of several digital skills (Butler, Ryan, & Chao, 2005).

Socioeconomic Status

Studies have shown that socioeconomic status correlates with an individual's own perception of digital literacy capabilities (Hargittai, 2010). Similarly, Jackson et al. (2008) found that students' socioeconomic characteristics were an accurate judge of the intensity and nature of the students' technology usage.

Race and Ethnicity

According to Hargittai (2010), race affects individuals' self-perceptions of their digital skills. Specifically, African American and Hispanic students rated their digital knowledge more poorly than did Caucasian students. Jackson et al. (2008) found similar differences between African American and Caucasian children in the intensity and nature of their technology use.

Several studies have suggested that race is not an accurate predictor of digital literacy. For example, Jackson et al. (2008) concluded that prior experience with technology is a better predictor. Further, Jackson, Yong, Witt, Fitzgerald, von Eye, and Harold, (2009) failed to identify a significant difference between participants of different races. Also, Jones et al. (2009) failed to find a significant difference between participants of different races.

Technology Experience

Researchers van Deursen and van Dijk (2008) found experience to be a significant predictor of an individual's digital technology capabilities. Both the number of years with technology access and the number of hours spent per week with technology positively relate to an individual's digital skills (Hargittai, 2010). Even students who had taken one advanced computer class did better on several technology assessments (Koroghlanian & Brinkerhoff, 2007). Similarly, the level of integration of technology in high school education has an effect on how much an individual will value technology later (Banister & Ross, 2006). However, some scholars counterpropose that previous experience with computers does not affect a student's digital literacy (Comber et al., 1997).

Education

Some scholars have stated that level and quality of education has an impact on digital literacy. Teske and Etheridge (2010) argued that honor students are more digitally literate than non-honors students. Although, van Deursen and van Dijk (2008) only found education to be a significant predictor of the time it takes to complete digital tasks. Bonfadelli (2002) contradicted the previous studies and claimed that education level cannot be used to predict digital literacy, but it can be used to predict how an individual may use it.

Education Majors' Multiple Intelligences and Digital Literacy

The digital and technological skills of teacher candidates vary greatly (Banister & Ross, 2006). For these teacher candidates to effectively integrate technology into their future classrooms, they must first acquire the skills themselves. Martinez (2010) similarly posited that education majors must learn the technology skills before they can teach it to others. Teaching cannot be as effective without successful implementation of information and communication technology (Ertmer & Ottenbreit-Leftwich, 2010).

Application of Multiple Intelligences to Digital Literacy

Digital technologies can effectively be used to teach students who have an assortment of intelligences. Gardner (1993b) commended the ability of technology to help students meet and surpass educational goals. He advised that students' primary intelligences should be matched with appropriate technology. This combination is likely to improve the students' learning (Gardner, 1995). Further, several scholars have listed specific digital tools and lessons that can advance the digital classroom experience (Gen, 2000; Grant, 1999; Leu et al., 1997; McCoog, 2007; Silver et al., 2000). Although empirical evidence in the literature is limited, it may be possible to predict a student's score on such digital assessments by knowing his or her dominant intelligence(s). For example, it was found that musical and verbal-linguistic learners performed more poorly in a class delivered online (Barbour & Cooze, 2004). Other scholars also have established that learning improves when the teacher matches the selected digital technologies with the students' intelligence profiles (Gen, 2000; McCoog, 2007). Overall, technology in the classroom is vital because it has an excellent capacity to engage and challenge students (Grant, 1999).

MATERIALS AND METHODS

The study sought to examine the relationship between pre-service education majors' multiple intelligence learning styles and their levels of digital literacy. A quantitative survey was employed for this study. The independent variable was the subjects' scores on a multiple intelligences assessment. The dependent variable was the subjects' scores on a digital literacy assessment. The alpha level for this study is $p = .05$.

Procedure

All participants were assigned a username and password for admittance to the digital literacy assessment. Students could not be identified by their usernames. All participants were enrolled in a digital technology course. Their instructors were not informed about which responses were made by any particular student.

Subjects in this study completed three stages of data collection. First, data was collected on the students' demographics. This step was administered to determine the heterogeneity of the sample. This step used a descriptive survey. This survey was administered online through Qualtrics.

Second, the students' learning styles were measured using an assessment developed by Gürcüm (2010). This survey was also administered online through Qualtrics.

Third, each participant's digital literacy was assessed through the Instant Digital Competence Assessment developed by Calvani, Cartelli, Fini, & Ranieri (2009). It was administered online through the Instant Digital Competence Assessment website. Students were required to provide their anonymous usernames for each step so their responses could be matched.

Setting

This study was conducted at Indiana University of Pennsylvania where education majors are required to meet the International Society for Technology in Education's NETS standards. The study was administered online.

Population and Sample

All participants (n =101) included in the study were enrolled in one of ten digital instructional technology courses. Participation in the study was voluntary. Students were not included in the sample if they had previously been enrolled in one of the courses. This was done to control for prior knowledge and to minimize threats to external validity. The survey was administered during the first two weeks of the semester.

Instrumentation

A seven-item descriptive questionnaire was used to describe the sample. The assessment measured several variables recognized in the literature review: age, gender, socioeconomic status, prior technology experience, education level, and race.

Each subject's multiple intelligences learning style was measured using a 142-item multiple intelligences inventory designed by Gürcüm (2010). The inventory was comprised of Likert-type questions. The instrument's coefficient of reliability is acceptable (.943).

The participants' digital literacy was measured through the Instant Digital Competence Assessment (iDCA) developed by Calvani et al. (2009). The iDCA was designed to match the authors' model of digital competence (Calvani et al., 2009).

The assessment was found to be valid by a panel of experts (Calvani et al., 2009). The instrument was found to have an acceptable level of reliability (Cronbach's alpha = 0.79).

RESULTS

The data was coded into an electronic spreadsheet. All data was merged into one electronic spreadsheet. The data was ordered by each participant's numeric username.
Several descriptive statistics were analyzed to describe the sample. This step examined the heterogeneity of the sample. Next, a Pearson's *r* correlation cross-tabulation was used to determine whether any of the eight multiple intelligence learning style categories correlated with digital literacy. Lastly, a multiple linear regression test was used to determine the degree to which the interplay between the eight multiple intelligence learning style variables predicted the score on the digital literacy assessment.

Description of the Sample

Several statistics were analyzed to describe the sample. The examined demographics were identified in the literature review: age, gender, socioeconomic status, prior technology experience, education level, and race. The statistics indicate that the sample is relatively homogenous.

Age

A majority of the students in the sample were between the ages of 18 and 20 (88.1%). Participants aged 21 years or older constituted 11.9% of the sample. No participants were under the age of 18.

These results were anticipated because most education majors at the host university are required to enroll in the digital instructional technology course during their freshman or sophomore years.

Gender

Most students included in the sample for this study were female (70.3%). Less than one third (29.7%) of participants were male.

Parental Education

A majority of students (77.2%) indicated that their parents' education levels included at least some college. Less than one quarter of the students (22.8%) stated that their parents had a high school degree or less.

According to Sewell (1971), this percentage of college-educated parents indicates that most of the participants in this study had a relatively comfortable socioeconomic status. Therefore, the students included in the sample for this study should have been capable of receiving an acceptable mark on a digital literacy assessment (Hargittai, 2010).

Technology Experience

Most participants (94%) signified that they had familiarity with digital technologies for at least 6 years, and a large proportion stated that they had at least 10 years of experience.

The students had a significant amount of experience using digital technologies. This is comparable to the findings of Smith et al. (2009; however, it does not indicate that the students are also digitally literate. Having access to digital technology does not denote acceptable digital literacy (Hargittai, 2010).

Education Level

A large majority (96%) of the participants held a high school degree and had taken at least one college course. A small proportion (4%) of this sample had previously earned a college degree.

Race/Ethnicity

The majority of respondents (94.1%) identified themselves as White/Caucasian. Small proportions identified themselves as Black/African American (4%), Hispanic (1%), and Asian (1%).

These distributions are not representative of the university. The ratio of White/Caucasian students to minority students is not as exaggerated (Crimson Snapshot, 2011). Because this was a volunteer sample, the results were generalized to a larger population.

The Multiple Intelligence Learning Styles' Relationship To Level Of Digital Literacy

A Pearson *r* correlation cross-tabulation statistic was used to determine if the eight learning styles correlated with the students' digital literacy capabilities. A significant, positive correlation (.188) was found between the participants' verbal-linguistic learning style and their level of digital literacy at the p =.05 level. However, the correlation is noticeably weak. The significance (.030) is similarly weak. However, because a positive and significant correlation between the two variables exists, the hypothesis is supported. Correlational analyses failed to find any level of significance between logical-mathematical, visual-spatial, musical-rhythmic, bodily-kinesthetic, interpersonal, intrapersonal, and naturalistic learning style and digital literacy. The hypotheses are, therefore, not supported.

The Multiple Intelligences Learning Styles as Predictors of Digital Literacy Capabilities

A multiple regression analysis was also conducted. The eight multiple intelligence learning styles were used as the independent variables. The students' scores on the digital literacy assessment were used as the dependent variable. This analysis sought to determine how well the multiple intelligence learning styles work together to predict an individual's digital literacy.

The multiple intelligences model as a whole was a poor predictor of the participants' digital literacy (r = .255). The low r-squared value (.065) similarly supported this finding.
The multiple regression results did not identify any significant correlations between each of the eight multiple intelligences and the digital literacy variable. The strongest coefficient was found with the verbal-linguistic variable (b =.062, p =.019). This was expected, given the significant finding of the Pearson *r* analysis. The multiple regression analysis minimizes this finding.

CONCLUSION

This section will summarize the outcomes of the previous chapter and include a discussion of the relationship between the eight multiple intelligence variables and level of digital literacy.

Verbal-Linguistic Intelligence

Verbal-linguistic intelligence was found to have a significant, positive correlation to the education majors' digital literacy. This contradicts the findings of Barbour and Cooze (2004), which indicated that verbal-linguistic learners perform more poorly in a digital environment.

Further analysis, however, determined that verbal-linguistic intelligence did not have a significant correlation with digital literacy. This does not support the theories of researchers who theorized that verbal-linguistic learners might perform well in digital environments (Gen, 2000; Jackson et al., 2009; Leu et al., 1997). This finding does not conflict with Gardner's (1983, 1995) notion that a learner's verbal-linguistic learning style should correspond with his/her score on a verbal-linguistic assessment.

The Remaining Learning Styles

The remaining multiple intelligence learning style variables did not significantly correlate with level of digital literacy. This finding contradicts the theoretical base of this study, which was developed from Gen (2000), Grant (1999), Leu et al. (1997), McCoog (2007), and Silver et al. (2000). When the eight independent variables were analyzed as a whole, none were found to have a significant correlation with digital literacy. These eight multiple intelligence variables are not accurate predictors of participants' level of digital literacy. A student's learning style should not be used to predict his/her score on a generalized digital literacy assessment.

Multiple Intelligences as a Model for Predicting Level of Digital Literacy

Gardner's (1983) claim that individualized instruction should be matched with similarly individualized assessment strategies is the foundation of the multiple intelligences theory. The use of a general (rather than individualized) assessment in this study also may explain why the learners' scores varied so greatly—a finding that is reinforced by the work of Banister and Vanatta (2006). Therefore, it is recommended that future studies in this area utilize an individualized assessment plan.

The Other Variables

Several other independent variables similarly were found to be poor predictors of the subjects' technology capabilities. Some of the findings (e.g., gender) support the findings of other notable studies. However, some findings (e.g., level of prior technology use) contradict findings that state that people with higher technology experience should score higher on an assessment of their technology skills. This was not seen in this study, however. Therefore, it cannot be suggested that any of the independent variables analyzed for this study can be claimed as accurate predictors of an education major's technology skills.

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Effect of pre-defined Color Rendering Intents (CRI) on the Hue attributes in a Color Managed Workflow (CMW)

By Dr. Haji Naik Dharavath and Uttam Kokil

ABSTRACT

The purpose of this study is to determine the influence of applied International Color Consortium (ICC) predefined color rendering intents on the digital printing solid colors output (Cyan, Magenta, Yellow, and Black ([CMYK]) hue and gray output (Overlap of CMY: 50%, 40%, and 40% tints) hue variation among the four ICC standard color rendering intents in a color management workflow (CMW). The experiment analyzed the effect of four ICC-specified color rendering intents (absolute, perceptual, relative, and saturation intents) on the digital color output hue of gray and solid colors. The objective of this study allowed testing of an accepted color management practice to gain a better understanding of the presumptions associated with the application of rendering intents. The experiment examined the four ICC color rendering intents as independent groups ($K = 4$) using a one-way analysis of variance (ANOVA) with equal n's method (at $\alpha = 0.05$) to determine the significant colorimetric variation (COLVA) of hue between the ($K = 4$, $n = 15$, and $N = 60$) group means (averages) color deviations of these intents. With four rendering intents (groups, $K = 4$), a one-tailed, non-directional hypothesis was established. The conclusions of this study are based upon an analysis of ANOVA test data and associated findings. The data from the ANOVA reveal significant differences in the gray hue deviation of the reproduction among the multiple ICC color rendering intents (CRI). The colorimetric data suggests that selection of a rendering intent is an important activity in a CMW as it relates to obtaining accurate output colors for a desired purpose.

Keywords: Calibration, Color, Colorimetry, Gamut, Profiling, Proof, Color Rendering

INTRODUCTION

Modern printing technology has evolved from the craft oriented field toward a color management science demanding greater color reproduction control among the devices used in the print and imaging industry. Graphic or printing workflow is represented through schematic illustrations of activities that reflect the systematic organization of analog and digital devices used during the print and image production process. In a quest to empower students to better understand the attributes of various hue variables, this work examined standardized rendering defaults similar to those a student would encounter through software that manages color manipulation and drives output (or printing) devices, such as a laser color printer, an inkjet printer, or a digital color press. Hence, for a student to consistently deliver a quality print, managing and controlling color from the input device to a multicolor output device is a major concern for the graphics and imaging educator.

Color can be viewed as a science where the optical aspects of color can be quantitatively analyzed and measured. The human eye, however, perceives color more subjectively, which poses a challenge at times for the print and image reproduction industry. Advancements in science and engineering, however, have allowed print and image professionals to apply scientific research methods across prepress, pressroom, and quality control areas. Teaching these methods to students will heighten their recognition of the importance of proper workflow. Unfortunately, the use of color management systems has not yet solved all of the problems of color reproduction (Fleming & Sharma, 2002), such as acceptance of linear colors, reproduction of neutral gray-balance, effect of rendering intents, level of ΔH or ΔE acceptance, and so forth. Hence, this has given rise to quantification of color problems (Fleming & Sharma, 2002).

Color Management System (CMS)

In a color-managed workflow, the device characterization is presented in terms of specially formatted files (known as profiles or device characterization). A CMS or a CMW uses a set of hardware tools and software applications to create accurate color among various input, display, and output devices. A CMS consists of device profiles (or characterization of devices), which control and document the working performance of the scanner, monitor, and printer. A device color transformation engine (color management module or CMM) interprets the color data among the scanner, display, and printer. The gamut compensation mechanism of the CMS addresses differences among the color capabilities of input, display, and output devices. The profile connection space (PCS) is a device-independent color space through which all color transformation occurs from one device-dependent color space to another (see Figure 1). The PCS is based on the spaces derived from CIE color space. Apple ColorSync supports two of these spaces: L* a* b* and XYZ. The color conversion from device-dependent color space to device-independent color space is achieved by the use of PCS. The device color characterization file (profile) passes in and out of the PCS to complete the transformation. The PCS of the CMS is the central hub of the CMS in which a particular color value is considered absolute and not subject to interpretation.

ICC Color Rendering Intents

According to ICC, color gamut mapping can be completed by one of the four ICC recognized colorimetric rendering intents: *perceptual, absolute, relative, and saturation*. The rendering intent determines how the colors are processed that are present in the source gamut but out of gamut in the destination (output). Rendering intents compiled by the ICC are "specifically defined for the purpose of cross-media reproduction using color management systems" (Morovic, Green, & MacDonald, 2002, p. 307). In essence, intents are large lookup tables (LUT) that prescribe the range of RGB or CMYK values to an output device. Because the 16.7 million color choices (224) in an eight-bit color scheme (RGB mode) or 4.3 billion color choices (232) in CMYK mode are unmanageable, intents are employed. Each rendering intent tends to be associated with select types of images and/or workflow stage situations, such as characteristics of the original, as well as reproduction media and its viewing conditions. These four intents– *perceptual, saturation, absolute colorimetric, and relative colorimetric*—are intended to produce uniquely different results and thereby have migrated toward selection based on general use guidelines (Green, 2010).

Perceptual, also referred to as the photographic rending intent, is said to emphasize retention of relationship between colors, whereas colorimetric intents are thought to be high accurate in-gamut colors and saturation that deliver more colorful images (Sharma, A., 2004). The aim of the perceptual rendering intent is generally to be pleasing, placing reproduction accuracy secondary while maintaining relationships between colors. This intent compresses or expands the gamut of the image to leverage attributes of the destination device. In this case, colorimetric accuracy may be compromised (Morovic et al., 2002).

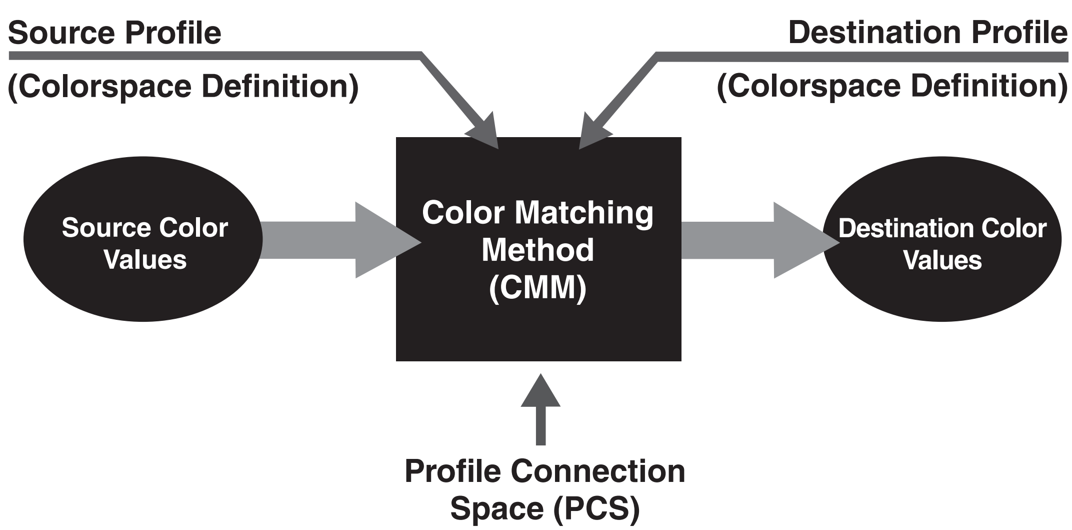


Figure 1. Schematic of PCS of CMS (Courtesy of Adobe Systems, Inc.)

Saturation rendering is believed to be the vendor-specific intent, because this technique is mostly used with graphics and text with little regard for color per se. By saturating the pixels in the image, hue and lightness are discounted. Similar to perceptual rendering, this intent seeks to adjust for different devices, media, and viewing conditions. Many researchers suggest that it is suited most for images that incorporate charts and diagrams (Sharma, G., 2003).

Absolute rendering intent strives to create exact colors. It is used to predict how an image will appear when printed on a specific substrate. In this situation, although colors that equate between the original and the print are unchanged, those out-of-gamut are clipped. With this intent, the reproduction will theoretically match the original if the paper matched. Proofing often uses this intent.

Relative colorimetric and absolute intents use clipping where a gamut boundary is forced. The relative colorimetric intent, however, relates to a white point on the substrate, best chromatically adapted to D50 conditions, and it adjusts all colors maintaining their relative position to white. Where matches between reproduction and original are sought, this intent often serves as the default.

It may be said that ICC rendering intents invite a heuristic application to a subjective solution. In contrast, psychophysiological evaluation techniques (also known as "the total experience"), have informed findings about colorimetric rending methods (Milkovic, Knesaurek, Mrvac, & Bolanca, 2004) and gamut-mapping algorithms alike (Braun, Bala, & Harrigton, 2005). These techniques seek to quantify perceptible change in color, though studies find that even though CIE describes ΔE of 1 as perceptible, the "average consumer would not detect any difference less than ΔE max value of 5" (Mason, 2007, p. 2). The use of visual qualitative analysis has informed the selection of rendering intents and is commonly a metric incorporated into research about digital proofing (Lin, Zhou, Lin, & Luo, 2009). Illustrative of the debate about generalizing intent usage, Green (2010, p. 28) suggested that, "it is not possible to standardize re-purposing transforms" as they hinge on subjectivity and viewer preferences. Furthermore, Green (2010) also stated that the perceptual and saturation intents are more about repurposing—producing a reproduction on a second medium where viewing conditions might be quite different. Yet, he suggested that the retargeting—intention of matching a reproduction on a different media is more suitable for colorimetric rendering intents.

Further compounding the challenge for color managers is device "personality" (Sharma, A., 2005), which seeks to couple standardized transforming methods (ICC rendering intents) and gamut mapping to establish quality validation. Gamut mapping applies a set of rules to produce the best color match, and rendering intent works to maintain color accuracy while also remapping non-reproducible colors (Berns, 2000). To systematically control for variance, color managers use industry intents that modify the input data by applying linear and nonlinear compression, various cutting techniques, and select algorithms in accordance with ICC standards (Milkovic, Bolanca, Mrvac, & Zjakie, 2006). In short, these intents take visual data from one source, mathematically manipulate this data based on a predetermined industry criterion, and direct that repurposed data to a select output device. Efforts to control device variance are a technological juggernaut for managers, given the characteristic differences of RGB and CMYK, electronic manipulation, and physical manipulation, respectively.

Lightness, Chroma, Hue (L*C*H) and Gray

Each color has its own distinct appearance based on hue, chroma (saturation), and value or lightness (X-Rite, 2007). By describing a color in terms of these three attributes, one can accurately identify a particular color and distinguish it from others. When asked to describe the color of an object, most people mention its hue first. Quite simply, hue is how people perceive an object's color, such as red, orange, or green (X-Rite, 2007). Chroma describes the vividness or dullness of a color: how close the color is to either gray or to the pure hue. For example, the red of the tomato is vivid, but the red of the radish is dull (X-Rite, 2007). The luminous intensity of a color (i.e., its degree of lightness) is its value. Colors can be classified as light or dark when their values are compared. For example, when a tomato and a radish are placed side by side, the red of the tomato appears to be much lighter. In contrast, the red of the radish seems to have a darker value (X-Rite, 2007).

The L* c* h* color space uses the same coordinates as the L* a* b* color space, but it uses cylindrical coordinates instead of rectangular coordinates. In this color space, L* indicates lightness and is the same as the L* of the L* a* b* color space, C* is chroma, and h* is the hue angle. The value of chroma C* is 0 at the center and increases according to the distance from the center (See Figure 2). Hue angle h is defined as starting at the +a* axis and is expressed in degrees; 0° would be +a* (red), 90° would be +b* (yellow), 180° would be –a* (green), and 270° would be b* (blue). Metric chroma C* and the Metric hue angle h* are defined by the following formulas (Morovic, et al. 2002):

Metric chroma: $$C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

Metric hue angle: $$h^*_{ab} = \tan^{-1}\left(\frac{b^*}{a^*}\right)$$

where: a*, b* are chromaticity coordinates in L* a* b* color space

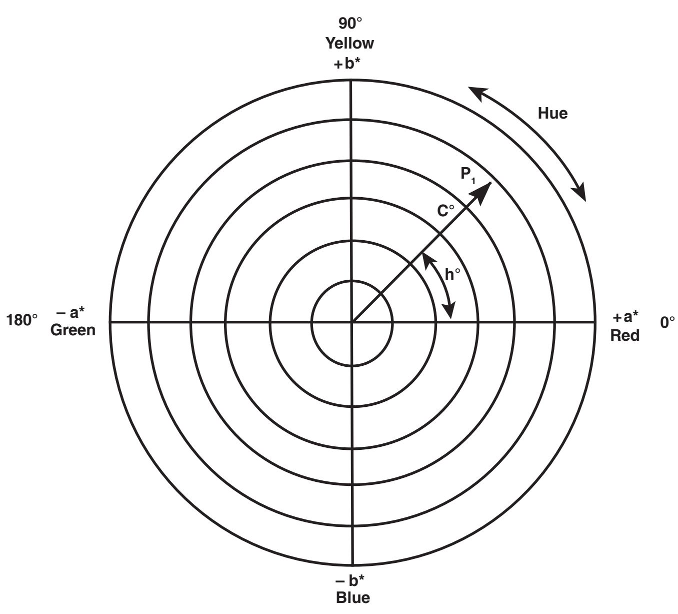
Gray balance is the proper percentage of combinations of cyan, magenta, and yellow inks that produce neutral shades of gray. Hue shifts will occur when there is any imbalance of one of the components. The imbalance is due in large part to ink impurities. Gray balance is a significant factor in determining overall color gamut. Gray balance can be determined by careful evaluation of a full set of tint charts printed with process inks. Colorimetric method is used to determine if the hue of gray is desirable in order to make sure that the black ink scale is neutral.Hue difference (ΔH*) is calculated by the following formula (Morovic et al., 2002).

$$= \sqrt{(\Delta a^*)^2 + (\Delta b^*)^2 - (\Delta C^*)^2}$$

$$\Delta H^* = \sqrt{(\Delta E^*ab)^2 - (\Delta L^*)^2 - (\Delta C^*)^2}$$

Purpose of the Research

The experiment was conducted in a color managed workflow to determine the printing colors (solid CMYK) and gray color (overlap of C = 50%; M = 40%; and Y = 40%) hue variation among the four ICC standard color rendering intents. It focused on the application of various color rendering intents to print color images by using CMYK dry toners on a digital color printing device that utilized a color laser digital printing technique (color electrophotography). The objective was to study the influence of applied color rendering intents in the printing color and gray color hue in a CMW. The following one-tailed nondirectional hypothesis



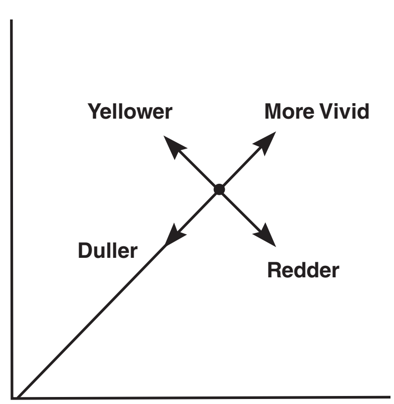


Figure 2. Schematic of L* c* h* Coordinates

was established, because of the multiple rendering intents (groups, K = 4).

> Ho: There is no difference (or relationship) in the printing CMYK ΔH and Gray ΔH (CMY overlap) of multiple color rendering intents, when the printed colorimetry is compared against the reference colorimetry.
>
> Ha: There is difference (or relationship) in the printing CMYK ΔH and Gray ΔH (CMY overlap) of multiple color rendering intents, when the printed colorimetry is compared against the reference colorimetry.

Limitations of the Research

For this experiment, there were limitations to the technology used within the graphics program laboratory. Prior to printing and measuring the samples, the digital color output printing device and color measuring instruments (spectrophotometer and densitometer) were calibrated against the recommended reference. The print condition associated with this experiment was characterized by, but not restricted to, inherent limitations. For example: colored images (IT8.7/4, ISO300, and ISO12647-7) chosen for printing, desired rendering intent applied, type of digital printer for proofing/printing, type of paper for printing, type of toner, resolution, and screening technique, use of predefined color output profiles, and calibration data applied, and so on. Several variables affected the facsimile reproduction of color images in the CMW, and most of them were mutually dependent. The scope of the research was limited to the color laser (electrophotographic) digital printing system (printing proof/printing) and other raw materials and the multiple types of color measuring devices and color management and control applications (data collection, data analysis, profile creation, and profile inspection) used at the university graphic communications laboratory. Findings were not expected to be generalizable to other CMW environments. It is quite likely, however, that others could find the method used and the data of this article meaningful and useful. The research methodology, experimental design, and statistical analysis were selected to align with the purpose of the research, taking into account the aforementioned limitations.

RESEARCH METHOD

The digital color output device used in this experiment was a Xerox DC250 CMYK printer

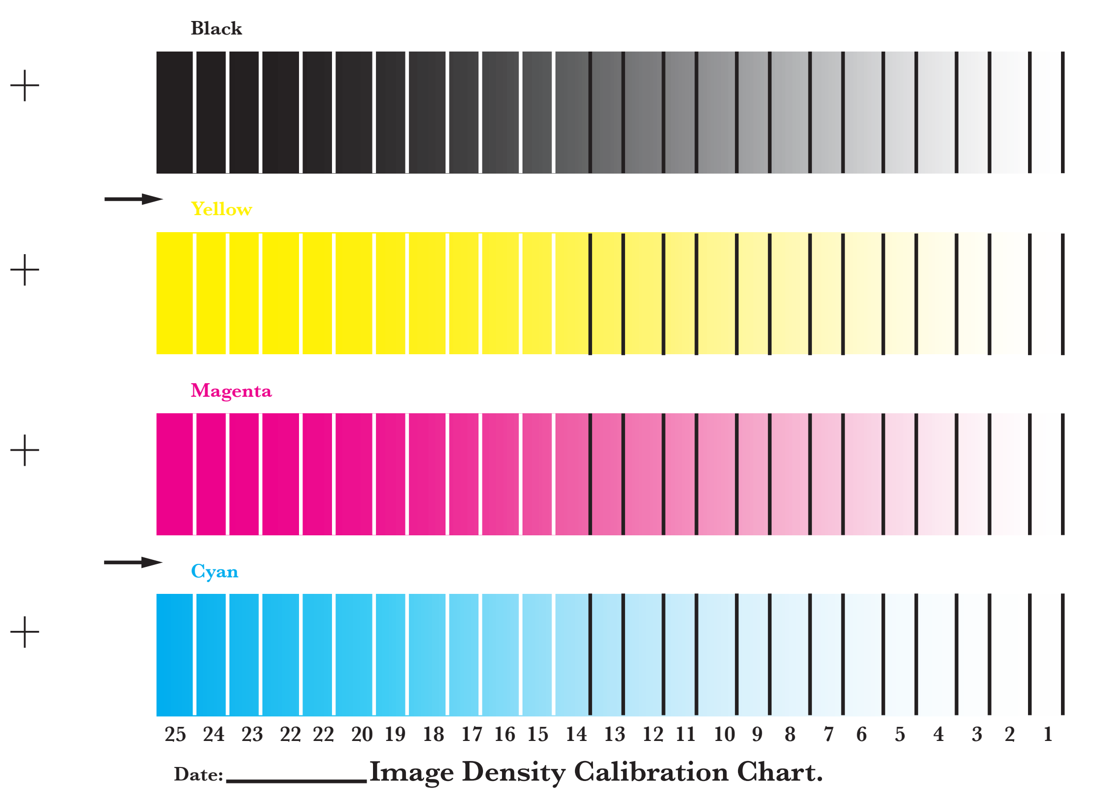


Figure 3. CMYK printer calibration chart (for Xerox DC-250)

(or digital press). It uses a Creo Spire CX250 raster image process (RIP) server (front-end system). This study utilized an experimental research method. MOHAWK brand 80 lb. matte-coated digital color printing paper was used. It was intended to determine the color differences of ICC rendering intents in a color-managed digital printing workflow. ICC specified color rendering intents are: absolute colorimetric rendering (ACR) intent, relative colorimetric rendering (RCR) intent, saturation rendering (SR) intent, and perceptual rendering (PR) intent. Each rendering intent in the experiment was considered as a group, noted by letter "K" (K = 4). Fifteen samples for each group were printed, noted by letter "n" (n = 15). For all the four groups, a total of 60 samples were printed, noted by letter "N" (N = 60). Multiple types of ICC standard based color management applications (software) and instruments were used in the experiment. A detailed method of this experiment is summarized in the following paragraphs. The digital color-printing laboratory made use of CMW for accurate color reproduction.

Printer Calibration

One of the important issues in getting acceptable print quality was the stable level of toner density (printer density). Fluctuation resulted from many controlled and uncontrolled variables, such as room humidity, temperature, printer settings, paper, age of toner, and inaccurate calibration or linearization of the printer. Therefore, calibrating the printer daily was very important. The calibration process for the printer used in the experiment was performed per the guidelines given by the device manufacturer. The CMYK calibration chart (with various tonal gradations) was printed without using any previous calibration data with 200 LPI (see Figure 3). An X-Rite DTP34 Scanning (Quick Cal) densitometer was used to scan the printed chart. The densitometer was calibrated against its reference chart prior to using it to calibrate the printer (or measure the chart). The calibration data (CMYK density ranges) was saved in the calibration lookup tables and a calibration curve was created (see Figure 4).

Test Image for Printing

A one-page custom test image of 8" x 10" size was created for proofing and printing use for the experiment (see Figure 5). The test target contained the following elements: an ISO 300 image for subjective evaluation of color, an ISO 12647-7 control strip, and a SpotOnPress! control strip. Colorimetric data was extracted from both the control strips. Color management settings were disabled in the Adobe InDesign CS-4 page layout application. All of the image elements were imported into the page layout program,

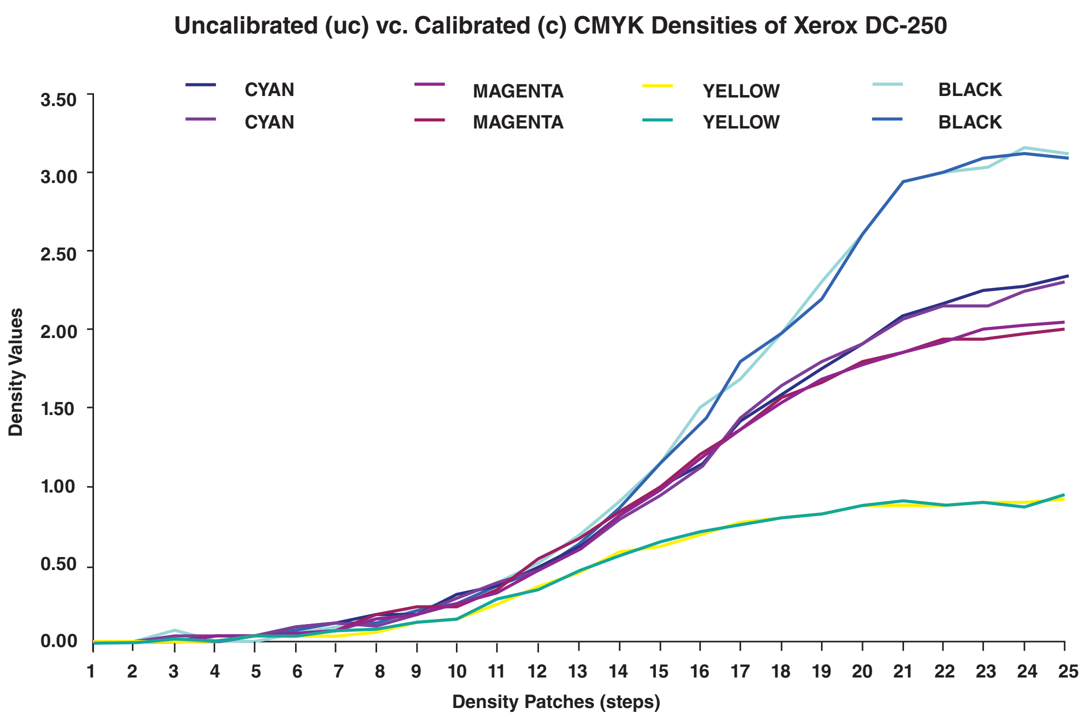


Figure 4. Uncalibrated vs. calibrated CMYK SID curve

and a PDF file was made without compressing the image data. The PDF file was sent to the Xerox DocuColor-250 Digital Press raster image processor (RIP). The press front-end system was powered by CREO Spire cx250 RIP, which runs on a Windows XP platform (Dell computer).

During the printing of the test image, in the color management option of the RIP, adjustments were made to print the test image, which included the following: a specific rendering intent, specific predefined (default) recommended profiles, lines per inch (LPI), and calibration data. In the CMYK emulation option of the RIP, adjustments were made to emulate the printing with a default profile and to print the test image with various ICC rendering intents. A recommended default destination profile was used to print the images. The device manufacturer recommended these two default profiles as predefined printing profiles. The final color printing/output was limited to these profiles, and other image color adjustment techniques were applied (rendering intents, LPI, calibration curve, etc.).

Printed Color Samples for the Analysis

A total of 60 prints (copies) were printed, 15 for each color rendering intent of the same image on 80 lb. matte-coated paper (K = 4, n = 15, N = 60). Colorimetric data for various color quantification for each group was generated from the printed colors (SpotOn! and ISO 12647-7 control strips) by using Eye-One-Pro spectrophotometer with interface applications, such as the SpotOnPress! and Fujifilm Taskero ColorPath Verified. Colorimetric data from SpotOn! was used to create the 2D gamut (profile) of the specific rendering intent. All of the four-color rendering intent 2D gamuts were mapped for the visual comparison (see Figure 5).

Measured colorimetric data (via Fujifilm Taskero ColorPath Verified) from an ISO 12647-7 control strip was used to determine the mean of CMYK ΔH and gray ΔH (CMY overlap) between the printed colors and its reference data (IT8.7/4). Data derived from ISO 12647-7 control strip (sample) is the difference between the characterization data set (full IT8.7/4 target) and the sample. A total of 60 measurements were made, 15 for each color rendering intent (K = 4,

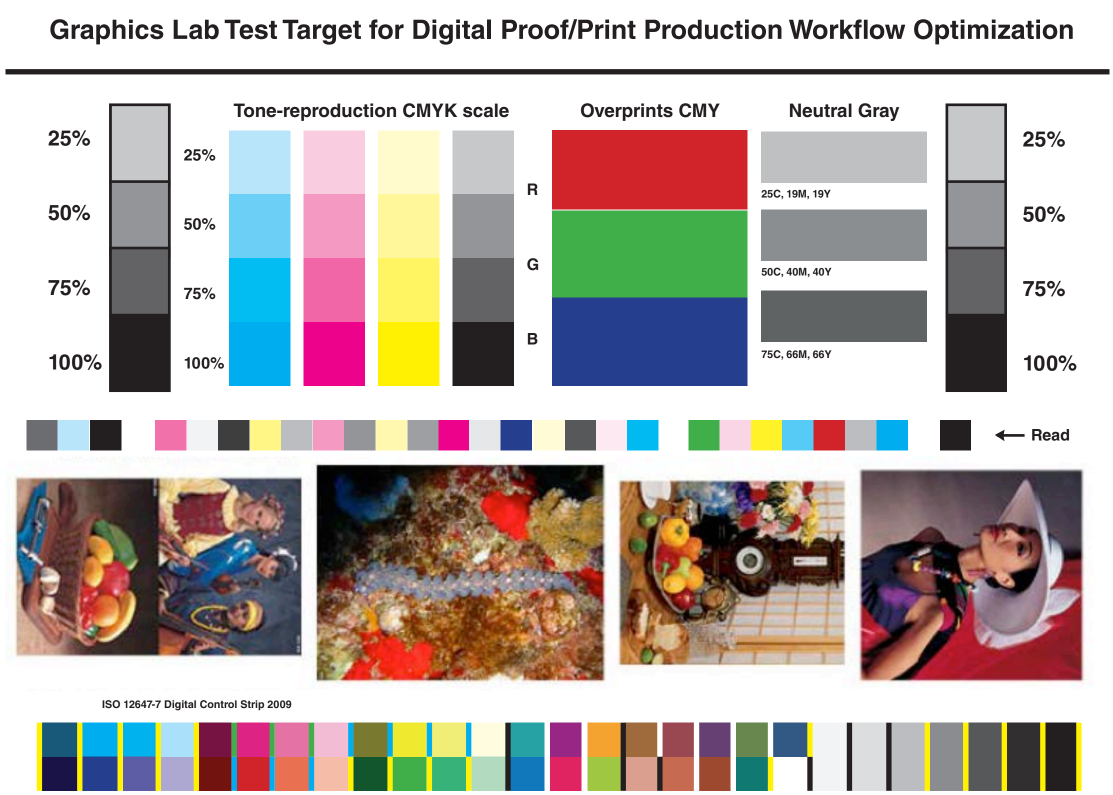


Figure 5. Test image for printing

n = 15, N = 60). The IDEAlliance ISO12647-7 control strip contained only a small subsample of IT8.7/4 target. It contained very little patches to prove an accurate match to a specific industry standard. However, it contained enough patches to monitor the accuracy of a color reproduction system against a reference target, such as the IT8.7/4. Table 1 presents the variables, materials, conditions, and equipment associated with the scanner, monitor, and printer of this experiment (see Table 1).

STATISTICAL METHOD APPLIED FOR THE EXPERIMENT DATA ANALYSIS

The Statistical Package for Social Sciences (SPSS) was used to analyze the collected data to determine the colorimetric variation (COLVA). Since the $K = 4$, a one-way analysis of variance (ANOVA) with equal n's method (at $\alpha = 0.05$) was used to determine the significant differences that exist among the ($K = 4$, $n = 15$, and $N = 60$) group means color deviations of the various color rendering intents (Glass & Hopkins, 1996). The F-test is calculated by using the following equation (Glass & Hopkins, 1996).

$$F = \frac{\sigma_b^2}{\sigma_w^2} = \frac{MS_b}{MS_w} = \frac{SS_b / V_b}{SS_w / V_w} = \frac{\sum n_k \left(\bar{X}_k - \bar{X}\right)^2 / K-1}{\sum \left(X_{ik} - \bar{X}_k\right)^2 / N-K}$$

When statistically significant effects were detected among the four groups, the Tukey method—post hoc ANOVA analysis was used to determine which group (K) means were significantly different. The Tukey method,

Table 1.
Experimental and Controlled Variables

Variable	Material/Condition/Equipment
Test images	A custom Test Target
Control strips	ISO 12647-7, and SpotOn!Press
Profiling Software	X-Rite ProfileMaker 5.0.10
Profile Inspection Software	Chromix ColorThink-Pro 3.0 & Apple ColorSync
Image Editing Software	Adobe PhotoShop CS-4
Page Layout Software	Adobe InDesign CS-4
Source Profile (RGB)	Adobe 1998.icc
Emulation Profile (CMYK)	SpireOptimized.icc
Destination Profile (CMYK)	SpireDC250.icc
Color Management Module (CMM)	Adobe (ACE) CMM
Rendering Intents	ACR, RCR, PR, and SR
Computer & Monitor	Apple Macintosh 10.5.8/LCD
Raster Image Processor (RIP)	Creo Spire x250
Printer	Xerox DocuColor-250 Color Laser
Uncalibrated CMYK SID	C = 1.71; M = 1.68; Y = 1.10; and K = 2.09
Calibrated CMYK SID	C = 1.19; M = 1.23; Y = 0.94; and K = 1.96
Screen Ruling	200 LPI
Print Resolution	2400 x 2400 DPI
Toner	Xerox Color Laser
Paper (sheetfed)	MOHAWK 80 lbs. matte-coated
Type of Illumination/Viewing Condition	D50
Color Measurement Device(s)	X-Rite Eye-One-PRO Spectrophotometer with Status T, 2° angle, and X-Rite DTP34 scanning Densitomter
Data Collection/Analysis Software	FUJIFILM ColorPath Verified, SpotOn! Press, and MS-Excel

also known as the honest significant difference (HSD) test between two sample means, can be determined by using the following equation (Glass & Hopkins, 1996).

$$q_1 = \frac{\overline{X}_1 - \overline{X}_K}{S_{\overline{X}}}$$

The *F* distribution and a probability value *p*, which is derived from the *F*, were used to determine if significant differences exist in the output color attributes of multiple color rendering intents. *F* is a ratio of two independent estimates of the variance of the sample, namely between the groups and within the groups ($K = 4$, $N = 60$). A low *p* value (or higher *F* value) is an indication that one should reject the stated null hypothesis (Ho) in favor of stated alternative hypothesis (Ha). This indication implies that one of the rendering intent means is significantly different. It suggests that there is a strong support that at least one pair of the rendering intent means is not equal. The higher the *p* value (or lower *F* value) indicates that the means of various color attributes of the color rendering intents are not statistically different. The value of *q* is the difference between the larger and smaller means of the two samples. Differences among the means at $p \leq 0.05$ are considered to be statistically significant among all the groups ($K = 4$) or color rendering intents. The main effect that the color rendering intents had on the digital color output in a CMW was determined by using the above-stated methods (*F* and *q*). The HSD multiple comparison test (with $\alpha = 0.05$) in the experiment enabled the researchers to identify the significant difference from one group to another. In other words, which color rendering intent differs significantly from one another?

DATA ANALYSIS AND RESEARCH FINDINGS

The ANOVA method was used to analyze the collected data. Color hue differences (ΔH) and gray hue differences were also derived to examine the noticeable color hue differences that exist among the various rendering intents. As stated in the previous section, the digital color prints (or proofs) printed with various rendering intents were analyzed by using ColorPath Verified against the IT8.7/4 reference data to determine the colorimetric deviations for Printing Colors Delta H (ΔH) and Gray ΔH

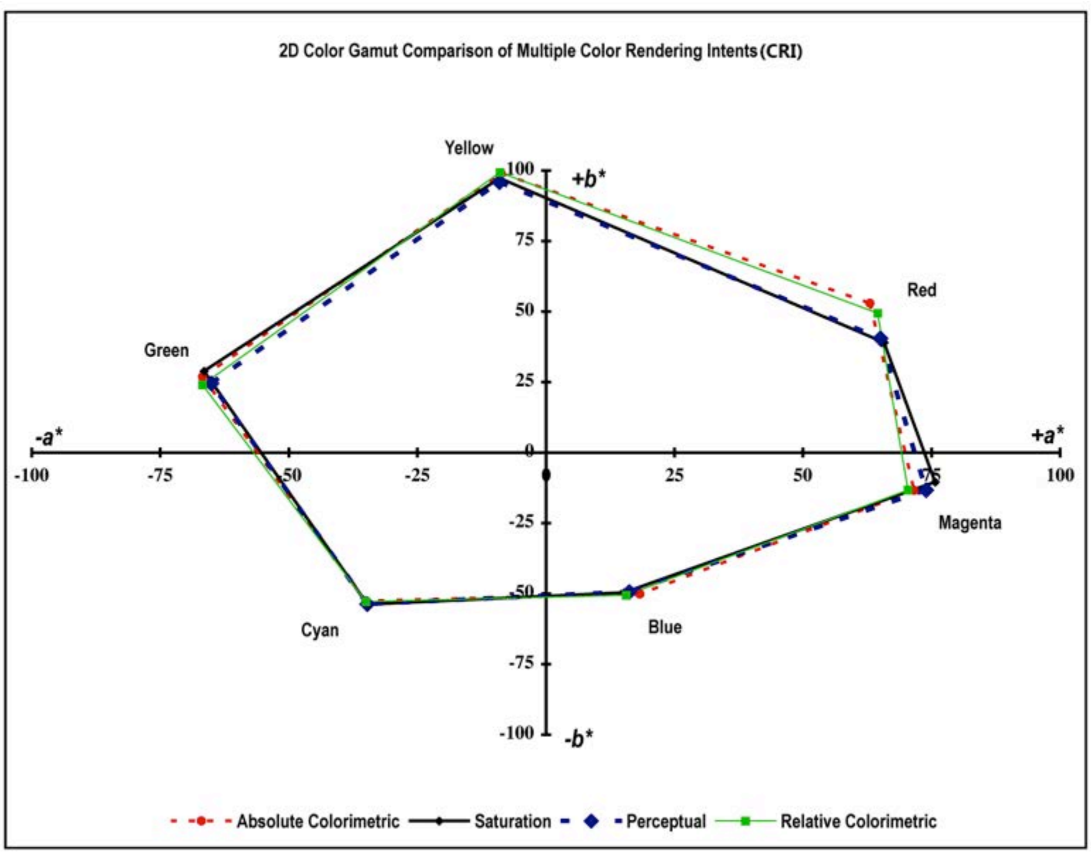


Figure 6. A 2D gamut comparison of multiple CRI

(CMY overlap). Average deviations of these attributes were mapped (bar chart) for visual comparison (See Figure 7). Colorimetric data from SpotOn! was used to create the 2D gamut (profile) of the specific rendering intent. All the four-color rendering intent 2D gamuts were mapped for the visual comparison (see Figure 6). Subjective judgment on color difference was not used in this study. The subjective judgment of color difference could differ from person to person. For example, people see colors in an image not by isolating one or two colors at a time (Goodhard & Wilhelm, 2003), but by mentally processing contextual relationships between colors where the changes in lightness (value), hue, and chroma (saturation) contribute independently to the visual detection of spatial patterns in the image (Goodhard & Wilhelm, 2003). Instruments, such as colorimeters and spectrophotometers, could eliminate the subjective errors of color evaluation perceived by human beings.

Printing Colors (CMYK) Hue Deviation (ΔH): Reference vs. Printed Colorimetry

The average primaries ΔH were different from one rendering intent to the other. As such, the ANOVA test was conducted to determine if there was any significant difference, $p \leq 0.05$ among the primaries ΔH of the rendering intents. The test showed that there was no statistical significant difference among the primaries ΔH, $F(3, 56) = 1.21, p = 0.31$; hence, the established hypothesis was accepted. This means, the applied color rendering intent did not significantly influence the primary colors ΔH (see Table 2) between the reference vs. printed colorimetric measurements. Post hoc analysis using Tukey HSD criterion for significance among the multiple color rendering intents primaries hue means was not required.

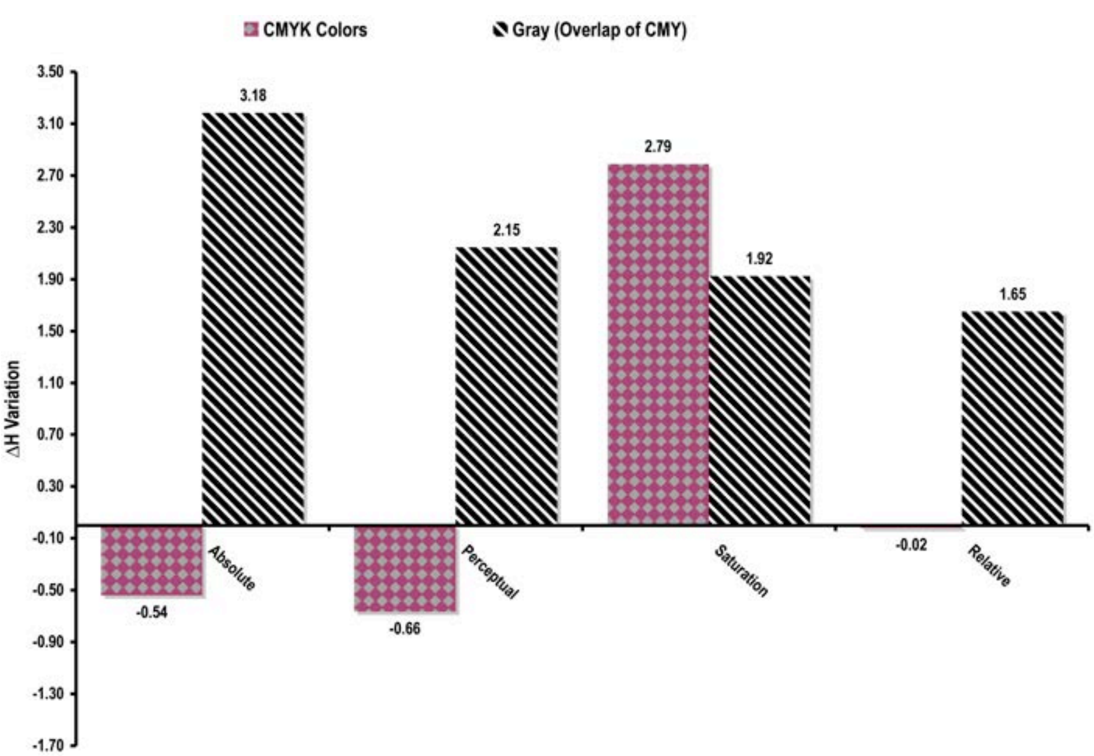


Figure 7. ΔH Comparison of multiple Color Rendering Intents (CRI)

Table 2

Summary of ANOVA for Multiple CRI Influence on the Primaries ΔH

Source of Variation	*Sum of Square*	*df*	*Mean Square*	*F*	*Sig.*
Between Group	118.26	3	39.42	1.21	0.31
Within Groups	1824.90 56	32.59			
Total	1943.16 59				

No Significant Difference [(α = 0.05 < 0.31) (F = 1.21 < 2.77)]

Gray Color (Overlap of CMY) Hue Deviation (ΔH): Reference vs. Printed Colorimetry

An ANOVA test revealed that there was a significant difference among the gray ΔH produced by each (multiple) color rendering intent, $F(3, 56) = 5.09$, $p = 0.000$. Data indicated that each of the rendering intents altered the printed gray colors differently. As such, the effect was significant at the $p < 0.05$ for all four rendering intents (see Table 3). Post hoc analysis using the Tukey HSD criterion for significance among the multiple color rendering intents means indicated that when comparing absolute rendering intent (1) with other rendering intents (3 and 4), there was a significant statistical difference in the gray ΔH produced by various color rendering intents (see Table 4) at the $p \leq 0.05$. The Tukey HSD test also indicated that the mean score of gray ΔH rendering intent 1 ($M = 3.18$, and SD = 1.40) was significantly different from the rendering intents 3 ($M = 1.92$, $SD = 1.02$), and 4 (1.64, $SD = 1.02$). The absolute rendering intent resulted in producing the highest gray ΔH, whereas relative rendering intent produced the lowest. No significant difference was found among gray ΔH mean scores of rendering intents 1 and 2 (absolute and perceptual) and 2, 3, 4 (perceptual, saturation, and relative).

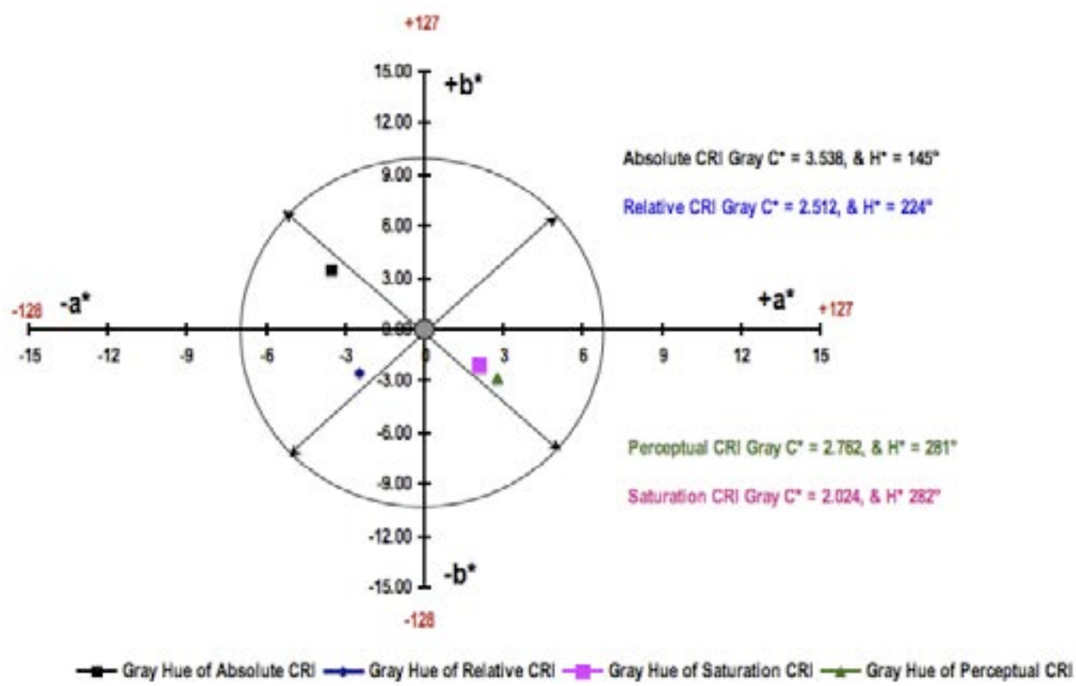


Figure 8. 2D gamut of gray hue and chroma angle position of multiple CRI

Table 3

Summary of ANOVA for Multiple CRI Influence on the Gray ΔH

Source of Variation	*Sum of Square*	*df*	*Mean Square*	*F*	*Sig.*
Between Group	20.18	3	6.73	5.09	0.000*
Within Groups	74.09	56	1.32		
Total	94.28	59			

**Significant Difference [(α = 0.05 > 0.001) (F = 5.09 > 2.77)]*

Table 4

Tukey HSD multiple comparison multiple CRI influence on the gray ΔH

Comparison	*Mean Difference*	*SD Difference*	*Sig.*
1 vs. 2	1.027	0.314	0.081
1 vs. 3	1.249	0.393	0.022*
1 vs. 4	1.525	0.393	0.003*
2 vs. 3	0.222	0.079	0.952
2 vs. 4	0.498	0.079	0.640
3 vs. 4	0.276	0.000	0.913

** p ≤ 0.05 and ** p ≤ 0.001 (1 = Absolute, 2 = Perceptual, 3 = Saturation, and 4 = Relative)*

CONCLUSIONS

This research demonstrates the use of ANOVA to determine the influence of applied ICC color rendering intents in the primary colors and gray color hue variation among the four ICC standard color rendering intents in a color management workflow (CMW) on the digital color output. The findings of this study represent specific printing or testing conditions. The images, printer, instrument, software, and paper that were utilized are important factors to consider when evaluating the results. The findings of the study cannot be generalized to other CMW. However, other graphic arts educators, industry professionals, and researchers may find this study meaningful and useful. For example, educators can implement similar models, the presented model, or this method to teach a color management module. The colorimetric data of this experiment led to the conclusion that the selection of a rendering intent of a choice is an important step in a CMW in order to output accurate colors of choice for a desired use/purpose.

The conclusions of this study are based upon an analysis of the ANOVA test data and major findings (data and experience of the experiment). The data from the ANOVA test revealed that there were significant differences in the color reproduction among the multiple ICC color rendering intents (CRI). No significant differences were found in the CMYK color hue deviation (ΔH) of solid printing colors of these four-color rendering intents. In other words, the chosen rendering intent did not influence the outcome of printing color hue variation. There were significant differences found in gray color hue variation. The ΔH was statistically higher for absolute colorimetric rendering when compared with other CRI. Also, statistically, it was found that there was no difference among the remaining color rendering intents gray hue variation.

Furthermore, the experience of the experiments (visual comparison) and analyzed data proved that there were no color differences among the printed samples (photographs, commercial, and digital printing) of rendering intents, such as the absolute, relative, and perceptual. One could achieve the same color output regardless of which rendering intent was used among the three (absolute, perceptual, and relative colorimetric rendering intents). However, one should be cautioned to use the saturation intent because this intent produced the highest color deviation when compared with other intents. Higher color deviations (ΔE or ΔH) mean that the printed colors could be out of established deviation tolerances. Numerous reports reveal that the saturation intent was the least used in the industry, because it merely tries to produce good colors without any concern for the color accuracy.

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Examining the Impact and Cognition of Technology on Pre-service Teachers of English in Swaziland

By Patrick M. Mthethwa

ABSTRACT

This study examined the impact and cognition of technology on pre-service teachers of English in Swaziland, where English is taught as a second language (ESL). Colleges and universities in Swaziland embarked on an initiative to equip pre-service teachers with technology skills. However, despite that every pre-service teacher who graduates from either a university or college must complete a module in technology, it has not been established if pre-service teachers perceive technology as useful, and if they are prepared to integrate it into their future teaching experiences. One hundred and thirty-five ESL pre-service teachers participated in this study. They completed a 20-item questionnaire that was later analyzed using quantitative methods. Subsequently, follow-up interviews were conducted with 23 participants. Overall, the results revealed that while pre-service teachers had positive perceptions of the usefulness of technology in language teaching, they were less likely to integrate technology into their language teaching experiences.

Keywords: Technology, English as a second language, computer-assisted language learning, pre-service teachers.

INTRODUCTION

Teachers of English as a second language, whether new or old, in the teaching profession would often agree that educational technology has infiltrated educational settings throughout elementary, primary schools, high schools, colleges, and universities. As a result, it is common to find different types of technology in schools, colleges, and universities around the globe; their curricula are continuously modified to accommodate changes advanced by educational technology. The introduction of technology in educational institutions has been realized in various forms, such as the introduction of information and communication technology (ICT). ICT in schools and institutions of higher learning is often inspired by a widespread and technocentric belief about the transformative nature of technologies (Watson, 2006). This belief nurtures the notion that technology changes the way we perceive realities in the 21st century, such as the way we teach and students learn. Thus, to a large extent, technology is seen as a "golden key" for facilitating technology-enhanced and student-centered teaching environments (Hannafin & Land, 1997).

Putting students at the center of teaching has become the hallmark for constructivist's theories. Essentially, there are many benefits of integrating technology with language instruction. A number of research studies such as Blake (2000); Brett (1997); Fin & Inman (2004) confirm that using technology in language teaching does benefit learners' educational outcome and their overall language proficiency. Also, learners' exposure to technology introduces them to a variety of online materials that are useful for authentic learning; these authentic learning materials are important to buttress instruction at any level of education. For instance, the use of multimedia, the Internet, and educational computer applications is associated with learners' motivation and autonomy (Armstrong & Yetter-Vassot, 1994; Blake, 2000; Brett, 1997; Pusack & Otto, 1990).

Motivation and autonomy are essential components of a desired student's learning behavior, synonymous with success in the language classroom. Each of these components keeps a student focused and goal oriented. However, not every researcher agrees that technology improves students' language proficiency, some studies report the contrary. For instance, authors such as Lasagabaster and Sierra (2003) and Stepp-Greany (2002) reported negative results about the adoption of technology to support language teaching. These studies, for instance, reported that no gains were found in students' language proficiency when technology

[1] The author is aware there are many types of technology tools. However, in this study, the author uses the word technology with reference to the use of computers in the classroom for educational purposes.

was used in the language classrooms. However, despite reported technology failures in some cases, technology has continuously gained popularity in many language-teaching contexts, including ESL.

In some ESL contexts, especially in developing countries, the popularity of technology has been a driving force for its adoption to support teaching. Because of limited educational resources, such as English language teaching materials in some ESL contexts, technology is used to buttress teaching and further alleviate the problem of insufficient teaching/learning materials. As a result, most ESL contexts prioritize the integration of technology with language teaching and, in some ESL cases, ICT is adopted to support instruction.

The success of integrating technology in ESL classrooms, however, depends on many factors, such as the availability of resources, teachers' dispositions about technology, technical support, and (to a certain extent) showing teachers how to implement technology in the classrooms. These factors are some of the determinants of whether or not the integration of technology in the ESL classroom will be successful. That said, teachers' positive cognition of technology is a centerpiece for guarantying the possibility of integrating technology with language instruction. If language teachers, for instance, raise serious concerns about technology, it is not a good sign that they will use technology in their language-teaching experiences. Liu, Theodore, and Lavelle (2004) noted that teachers' concerns about technology negatively affect the adoption and the integration of technology into teaching. Therefore, positive cognition of technology is a cornerstone for its successful integration into the classrooms, and the reverse is true.

ICT Initiative in Swaziland

Because of the belief that technology has capabilities of improving instruction in ESL, educational institutions in Swaziland embarked on an initiative to improve teaching by using technology. As a result, the Ministry of Education took major initiatives to introduce technology to support instruction in schools, colleges, and universities. These initiatives have been realized in many forms. For instance, UNESCO, the Swaziland Computer Education Trust (CET), and the Open Society Initiative for Southern Africa (OSISA) donated computers to schools, with the aim of improving education and overall instruction in Swaziland. CET installed 20 computers in 40 schools and provided technical support for each school (Ministry of Education Report, 2008). These computers have been used to support both teaching and learning in the recipient schools. Recently, an initiative by the Ministry of Education to integrate technology to support instruction has been the focus of current educational policies and strategic plans. Essentially, the strategic plans require institutions of higher learning to restructure their curriculum to accommodate technology. Thus, in teacher education colleges, the Ministry of Education built computer laboratories and installed over 40 computers in each college's computer laboratory as a way of implementing the strategic plan, and these computer laboratories are used as ICT centers. Every student who enrolls in the teacher colleges is expected to take ICT as a component of this program of study (Ministry of Education Report, 2008). The rationale behind encouraging every college student to take ICT modules is to ensure pre-service teachers are computer literate and can integrate technology into their future teaching experiences. The major challenge though is whether or not pre-service teachers in Swaziland share the same vision with the Ministry of Education, regarding the objectives of the ICT initiative.

The Status of English in Swaziland

English is a second language in Swaziland. It is used as both an official language and medium of instruction in schools. The status of English in Swaziland makes teaching it a huge task because there is a lot expected from teachers of English. Precisely, English-language teachers are viewed as the "heart" of the entire education system. The use of this metaphor describes the situation at its best. Like in the body, when the heart fails, all the other organs become dysfunctional. In Swaziland's case, the heart is English language and the other organs are the other subjects, such as geography, science, math, literature, and science, to name but a few. Thus, teachers of English have a task for scaling up the learning of English, by equipping students with language skills essential for upscale performance across the entire curriculum. For instance, in a geography class it is expected that a student should distinguish a question that requires him/

her to describe, from one that requires him/her to discuss. For each question, the student should know the relevant intellectual skills involved, and these intellectual skills are grounded on analytical knowledge acquired from English-language classes. As a result, students who are proficient in English have greater chances of performing well across all the disciplines, and the reverse is true.

Overall, in Swaziland, English-language teachers are largely responsible for preparing students to perform well across all the disciplines and, on top of that, to ensure students are proficient in both spoken and written forms of English. However, there are challenges English- language teachers encounter in ensuring that this task is executed properly. The challenges range from insufficient teaching materials to lack of exposure to authentic cultural target language materials, usually available on the Internet. As a result, ESL teachers in Swaziland rely on textbooks that eventually deprive learners of the significance of authentic voices of the target language, which are provided by online educational videos. Therefore, when the Ministry of Education took the initiative to introduce technology in teacher colleges and universities, the idea was to ensure that pre-service teachers access more materials to support teaching; it was also to orient learners to technology in schools. However, ever since technology was introduced in teacher colleges, it is not known if pre-service teachers perceive technology as a useful tool for supporting instruction, albeit evidence that teachers' use and knowledge of technology are significantly related to their perceptions (Atkins & Vasu, 2000). The more at ease teachers are as they use technology, the more they develop positive perceptions of technology, leading to its integration with instruction (Lam, 2000).

THEORETICAL FRAMEWORK

This study examined the impact and cognition of technology on pre-service teachers of English in Swaziland, using existing theories of the adoption of technology. As stated in the previous paragraph, ever since the introduction of ICT in teacher colleges in Swaziland, little is known about the impact of technology, pre-service teachers' perceptions of technology, and its integration into language teaching. Also, it is not known how critical decisions that evolve around pedagogy, policy, and the curriculum are influenced by research findings. The lens through which this study investigated the phenomena is the diffusion of innovations theory.

The diffusion of innovations theory focuses on the process by which innovation is adopted and accepted by individuals or members of a community (Rogers, 2003). This theory represents a number of subtheories, such as the systems and change theory (Fullan, 2001) that were relevant for this study. The system and change theory advances the idea that schools are decentralized organizations, with systems embedded in it. The embedded systems are students, teachers, classrooms, and other subsystems, whose primary function is to ensure that the schools deliver essential services to students, realizing goals and mission statements. The study therefore adopted this theory to investigate the overall phenomena, within which preservice teachers, ESL students, and the education system in Swaziland work together to realize educational goals, strategic plans, and mission statements. However, because the diffusion of innovations theory could not explain causation in this study, the grounded theory (Strauss & Corbin, 1990), mainly the constant comparative method was used to explain causation.

RELATED LITERATURE

Beginning teachers often view the integration of technology with language teaching as a distractor that destabilizes the classroom routine, including norms and space (Somekh, 2008). These routines are subconsciously established by both the traditional way of teaching and, sometimes, by the mentoring teacher. Unfortunately, traditional ways of teaching do not provide spaces for technology because they are much older than the advent of technology, and teachers who are accustomed to the traditional ways of teaching often think of technology as a distractor (Williams et al., 2011). As a result, some teachers develop negative perceptions of technology due to the notion that technology is a distractor. Researchers in this area, such as Yildirim (2000), attest that appropriately designed teachers' training programs are essential in shaping teachers' perceptions and cognition of technology. Also, some studies, such as Egbert, Paulus, and Nakamichi (2002);

Lam (2000); Oh and French (2007) found that the results of a meticulously developed teachers' training program accounts for teachers' improved technology capabilities and increased levels of confidence, leading to the adoption of technology in language classrooms.

There are many factors, however, that affect pre-service teachers' perceptions of technology and integrating it into their teaching practices. For instance, teachers' attitudes toward technology have a significant influence on the adoption of technology (Atkins & Vasu, 2000). As a result, perceptions and attitudes toward the use of technology have been studied from both sides, that is, from learners and teachers. From the side of learners, Torkzadeh, Pfughoeft, and Hill (1999) observed that perceptions and attitudes toward computers influence an individual's mind or frame of reference. Their study reported that learners' exposure to computers or computer-related devices at an early age influenced their perceptions and attitudes toward technology later. Conrad and Munro (2008) added that someone with a negative experience and low efficacy of technology may eventually form negative cognition about technology and, in a worse scenario, avoid thinking about or contact with technology.

From the teachers' side, researchers such as Kim (2002); Redmond, Albion, and Maroulis (2005) noted that critical factors affecting the successful integration of technology into the language classrooms were largely associated with teachers and not the learners. Thus, Kim (2002) contended that teachers' perceptions of technology could either inhibit or enhance its adoption. To a certain extent, whether teachers' perceptions of technology inhibits or enhances its adoption is a function of the teachers' background and orientation with technology. Redmond, Albion, and Maroulis (2005) noted that teachers' personal backgrounds are important factors in determining the adoption of technology. Several factors are essential in establishing positive cognition of technology and its adoption. For instance, studies such as those by Lee and Son (2006); Shin and Son (2007); Suh (2004); and Yildirim (2000) posited that factors such as availability of computer facilities, students' easy access to technology facilities, and teachers' prior experiences with ICT or similar programs are strongly related to either the success or failure of the adoption of technology.

In addition to the list of factors affecting teachers' cognition of technology suggested by the researchers in the previous paragraph, there are myriad other factors. These factors include large classes of students, insufficient or restricted work stations, slow-processing computers, frequent computer freezes, and lack of technical support, including peer support. These factors impact the success of the adoption of technology and compromise the teachers' positions regarding its integration with instruction. Also, teachers' previous exposure to any form of technology, such as ICT, determines their perceptions of technology (Egbert, Paulus, & Nakamichi, 2002). Teachers' previous exposure to technology may be a function of work experience, training, or curiosity about technology and its uses. For instance, Egbert, Paulus, and Nakamichi (2002) noted that teachers with previous technology experience are likely to integrate technology activities into their teaching.

Furthermore, Warschauer (2003) noted that technology tools such as computers are powerful tools to use in supporting students with low language proficiency. In other words, students benefit from using technology, both inside and outside the classroom. Inside the classroom, computers promote individualism and independence from a single source of information, whereas outside the classroom students use computers to access unlimited amount of educational resources (Blake, 2000; Kuang, 2000; Loucky, 2005). Therefore, technology provides invaluable benefits to students; it affords interactive, collaborative, and socially situated features on the Internet (Kramsch & Anderson, 1999; Mallette & Mthethwa, 2012). Armstrong, Yetter-Vassot (1994) and Blake (2000), for instance, reported that students' exposure to technology offsets limits set by geographical boundaries. From one point of view, Kramsch and Anderson (1999) reported how Messenger, Skype, and Second Life facilitated discussions across cultural boundaries. On the contrary, and despite these documented advantages of using technology in class, some studies such as Lasagabaster and Sierra (2003) and Stepp-Greany (2002) reported failure in using technology for learning. For instance, these studies reported that technology did not improve the learners' knowledge dispositions. However, be that as it may, there is documented evidence that technology does benefit learners around the globe, in terms of opening new language-learning experiences (Blyth, 1999; Bradely & Lomicka, 2000). Also, technology bridges diversity in students' cultural backgrounds that is now a common feature in 21st century classrooms.

TECHNOLOGY CHALLENGES IN AFRICA

The use of educational technology in Africa is not as vibrant as it is in developed countries. In developed countries, for instance, technology is used in many educational settings, for various purposes, ranging from registration for classes to actual teaching of specific content materials. In contrast, in developing countries such as Swaziland, the use of technology is still limited to basic skill development. That is, teachers use technology minimally, especially when it is used to access and retrieve online materials for supporting instruction. In some places though, such as South Africa, the use of technology (i.e., ICT) is thriving, and as a result, the role of technology is documented. For instance, Jaffer, Ng'ambi, and Czerniewicz, (2007) noted:

> ICTs can play a role in shaping curriculum design at the micro-level. ICTs open up new ways of accessing information thereby changing the relationships between students and between students and their teachers. Access to primary sources in the form of video, audio and photographs that may be contained in digital archives have the potential to influence the content of curricula because it makes previously inaccessible information available. In addition, ICTs enable lecturers to transform their teaching practices by facilitating student-student discussion and collaboration or by simulating 'real-world' problems thus providing students with authentic learning experiences. (p. 6)

In Swaziland, however, there are still many challenges facing the use of technology. These challenges range from lack of infrastructure to lack of qualified personnel who are knowledgeable in merging technology with the curriculum to support content area instruction. Also, some students come from diverse cultures and underprivileged backgrounds. As a result, some students come to schools, colleges, and universities with technology phobia or even stereotypes, some of which are detrimental in learning environments. A majority of students, for instance, start using technology when they come to educational settings such as schools, colleges, and universities. Otherwise, before they come to these institutions, some know little about using technology, especially computers. That problem notwithstanding, and as noted before, attempts have been made by the Ministry of Education to provide opportunities for computer literacy to all college and university students. Thus, the introduction of technology to colleges and universities, especially with regard to pre-service teachers, is to realize this goal and also to ensure that the use of technology is extended to all classrooms, from primary to high schools.

The Present Study

As observed by Atkins and Vasu (2000), teachers' cognition of technology is an important determinant of the integration of technology with instruction. For this reason, first, this study investigated if there were similarities between pre-service teachers' perceptions of the usefulness of technology and using technology for language teaching. Second, the study investigated if there was a relationship between pre-service teachers' perceptions of the usefulness of technology and using technology in their future teaching experiences. Third, the study investigated if there was an interaction by age and year of study on how pre-service teachers perceived integrating technology with language teaching. Lastly, the study investigated if pre-service teachers were likely to use technology in their language teaching, and why. The fourth qualitative question actually came as a follow-up question, arising from the quantitative data analysis.

METHODOLOGY

This study was a mixed method research design. It used both quantitative and qualitative modes of inquiry. This design was useful to understand the phenomena under study more broadly, than if one research paradigm (i.e., quantitative or qualitative) were used (Johnson & Christensen, 2012). For this study, the mixed method research design was appropriate; it allowed complementary strengths between the quantitative and qualitative components (Creswell, 2003; Johnson & Christensen, 2012).

As a result, combining these modes of inquiry expanded the breadth of this study. Overall, the study used identical samples for both the quantitative and qualitative inquiries. Data for this study was collected sequentially. That is, the quantitative data was collected first, and the qualitative data was then collected.

Participants

This study surveyed 135 pre-service teachers (n =135) from Space Teachers' College (STC) in Swaziland. This included 73 females (54.1%) and 62 males (45.9%). They were between 20 and 39 years of age. Students who enroll at STC must complete high school, obtaining grades between A and D in primary teachable subjects such as English, math, home economics, sciences, and social studies. Because of a backlog of applications every year, students wait for several years before they are admitted to the college. Thus, the college rarely admits new graduates from high school, and this explains why there is large variability between the participants' ages in this study. The typical length for the program of study at STC is three years, after which the graduates are certified to teach in primary schools. Every student from first to the second year must enroll in academic communication skills (ACS), English language, and literature. Even though in the third year students specialize in different concentration areas such as languages, sciences, social studies, math, and applied sciences, they still must enroll ACS as a component of their study. As a result, during this study, all participants were enrolled in at least one of the English language courses.

Instrument

The instrument used in this study was a 20-item questionnaire, which was developed for this study. In the questionnaire, three items asked participants' demographic information such as age, gender, and year of study, while 17 items asked construct-related information. The continuum on each item ranged from 1 to 5. One was the lowest score and five was the highest score. The rating was assumed to be interval with higher values indicating more endorsement

Table 1. *Reliability Statistics*

Cronbach's alpha	*Standardized*	*Number of Items*
.675	.718	16

[2] Space is a pseudo name for the teachers' college where data was collected.

Table 2. *Scaled Items: Mean, Standard Deviation, and Total.*

Scaled Items	***M***	***S D***	***N***
Technology makes language learning interesting	4.20	0.83	20
Technology motivates learners	3.90	1.07	20
Technology provides new learning experiences	4.45	0.76	20
Technology provides opportunities for language learning	3.95	0.89	20
I am familiar with Google documents	3.70	1.34	20
I am familiar with online dictionaries	2.00	1.34	20
I am familiar with PowerPoint	3.15	1.50	20
I am familiar with YouTube	2.05	1.36	20
I can use technology to download teaching material	4.75	0.55	20
I can use technology to keep students grades	4.85	0.37	20
I can use technology to prepare lessons	3.35	1.09	20
I can use technology to search material on the Internet	4.30	0.98	20
I will use technology to teach reading	3.35	1.27	20
I will use technology to teach grammar	4.05	1.10	20
I will use technology to teach speaking	3.10	1.29	20
I will use technology to teach vocabulary	4.25	0.97	20

of the statement. The values on the rating scale were based on an underlying continuum defined by the anchors and typically in a more ascending way, reflecting more of the property being rated as one goes higher on the scale (Gamst, Meyers, & Guarino, 2008).

Before the study was conducted, the instrument was tested on 20 pre-service teachers, who did not become part of the study. Cronbach's alpha was conducted to estimate the internal consistency of the items. The coefficient alpha for the 17 items was 0.683. However, one item was removed from the instrument because it did not measure the intended construct. Therefore, 16 items remained, excluding items on demographic information. The remaining items' overall internal reliability increased to 0.718, which is acceptable for conducting research (Nunnally, 1994). Table 1 shows the reliability statistics, and Table 2 shows the mean, standard deviation, and total number of the norming participants.

Data Analysis

Data were analyzed using quantitative methods. A sample *t*-test was conducted to establish if there were similarities between pre-service teachers' perceptions of the usefulness of technology and using technology for language teaching. For the second analysis, Pearson *r* correlation coefficient was conducted to establish if there was a relationship between pre-service teachers' perceptions of the usefulness of technology and using technology for language teaching. And lastly, the analysis of variances (ANOVA) was conducted to determine if there was an interaction by age and year of study on how pre-service teachers perceived integrating technology with language teaching.

RESULTS

Because the study was a sequential mixed method design and collected two sets of data, the results are presented in the same logic, starting with the quantitative portion and then the qualitative portion. However, later in the discussion section, the findings from both data analysis are triangulated and synthesized.

QUANTITATIVE RESULTS

The results for the first research question revealed that there were no similarities but differences between preservice teachers' perceptions of the usefulness of technology and using technology for language teaching, and the differences were significant. Table 3 presents the results for the first research question.

As shown by Table 3, the mean for perceived usefulness of technology ($M = 48.11$, $SD = 7.92$) was significantly greater than the mean for potentially using technology for language teaching ($M = 36.43$, $SD = 6.70$, $t\ (134) = 16.97$, $p = .001$ (two-tailed). It should be noted that having significant differences between these variables in this study is an indication that teachers were less likely to use technology for language teaching, even though they thought highly of its usefulness. The second research question investigated if there was a correlation between pre-service teachers' perceptions of the usefulness of technology and using technology in future language teaching. The results are presented below.

As shown by Table 4, there was a positive correlation between participants' perceptions of the usefulness of technology and using technology for language teaching, $r\ (134) = 0.412$, $p = .001$. That is, as their perceptions of the usefulness

Table 3. *Usefulness and Potential Use of Technology for Instruction*

Category	*N*	*M*	*SD*	*Min*	*Max.*	*t*	*Sig (2-tailed)*
Usefulness of technology in teaching	135	48.11	7.92	28.00	48.11	16.97	.000**
Potential use of technology in teaching	135	36.43	6.70	15.00	36.43		

Note: * = significant at alpha < .025; ** = significant at alpha < .001

of technology increases, the potential to use technology for language teaching also increases. The third research question investigated if there were interactions between age and year of study on how the pre-service teachers perceived the usefulness of technology for language teaching. ANOVA was conducted to investigate if there were interactions between these variables. Prior to conducting the main analysis, Levine's test was performed to check for violations of the assumptions of homogeneity of variances, F (5, 129) = 0. 560, p = 0.73. Since Levine's test was insignificant, ANOVA was conducted with no concern for any violations. The results for research question three showed an interaction in year three (see Figure 1). However, the interaction was not significant, F (1,129) = 1.44, p = 0.23.

As shown by Figure 1, pre-service teachers between 30-39 years in both first and second year had better perceptions of using technology in the ESL classroom compared to their counterparts whose ages were between 20-29 years. However, in third year, the reverse was true. That is, the third-year pre-service teachers between 30-39 years fell below their counterparts of ages between 20-29 years. This sharp decline is indeed a cause for concern.

Table 4. *Correlation*

Paired Items	*N*	*Correlation*	*Sig.*
Usefulness of technology versus its use for language teaching	135	.412	.000**

Note: * = significant at alpha <.05; ** = significant at alpha < .001

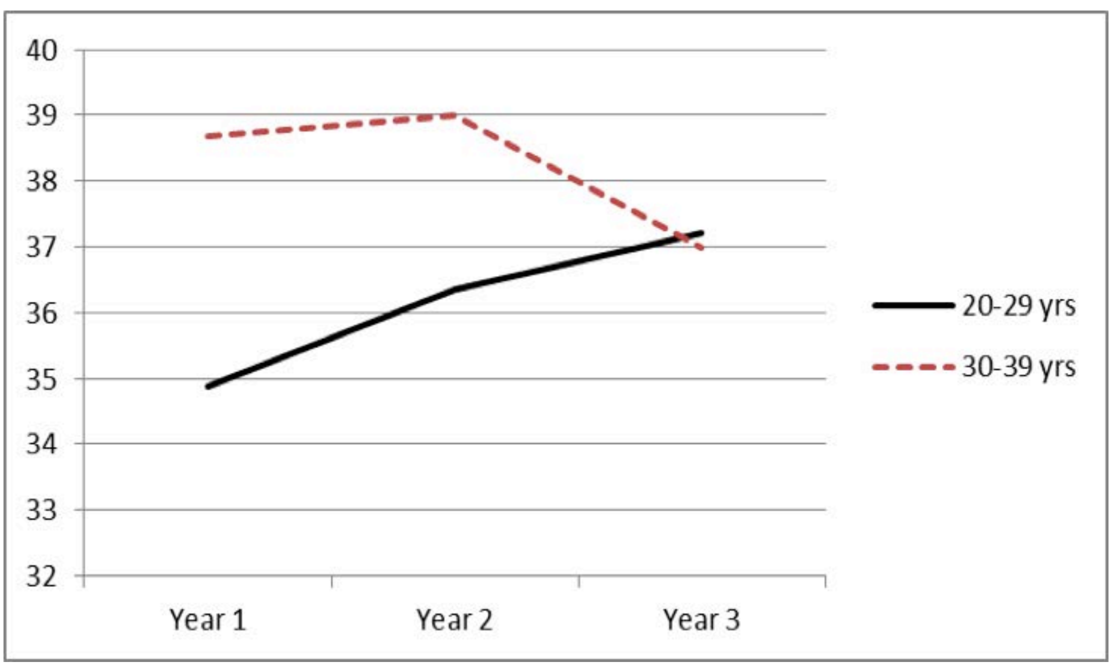

Figure 1. Interaction between Year of Study and Age

QUALITATIVE RESULTS

The last research question investigated if the pre-service teachers were likely to use technology to teach English in their schools, and why? This question came as a result of the quantitative data analysis, which showed that pre-service teachers were less likely to use technology in language teaching. Therefore, follow-up interviews were conducted with 23 participants, who had taken part in the quantitative data collection. Data emanating from the qualitative question were analyzed using the constant comparative method. The overarching theme that emerged from the interviews was that participants were less likely to use technology to support language teaching, and the reasons they gave revolved around the following thematic categories: class size, practice time, Internet speed, and power outage.

Class Size

Most of the participants noted that the ICT classes were large. For example, there were over 40 students in each ICT class, and there was only one instructor who helped them each time they encountered technical problems. Also, some participants highlighted that technical problems took a toll during their material learning time. As a result, they were not confident that they could use technology to teach. They emphasized that since most of them did not have background knowledge of using computers, they needed support from time to time during the ICT lessons. But because of the large number of students, they waited for a long time to get technical support from the instructor. In relation to the size of the classes, one participant stated:

> The classes are big, big, I mean big because now more students are admitted at STC. If I have a problem at my workstation, sometimes I wait for more than 3 minutes before the instructor can reach my workstation. Sometimes, as soon as he leaves, I encounter other problems, and it takes time for him to come back to me, and I understand, he has to help other students too.

Moreover, the participants also noted that each workstation, for instance, had about six students and most of them encountered technical problems. So, if they cannot help each other (peer support) to solve the problems, they all wait for the instructor to attend to them.

Practice Time

Another reason the participants gave for being less likely to integrate technology into their teaching was that they don't have enough practice time, apart from class time. As a result, they do not get an opportunity to reinforce previously learned materials. For instance, during the day when the computer laboratory is open, they are in other classes. In the evening when they get time for practice, the computer laboratory is closed, and when they go to class the next day, they usually start a new topic. So, they do not get enough time for individual practice. When one participant was asked what major changes he would like to see concerning practice time, he said:

> I wish the computer laboratory could be open in the evenings and weekends because most of us live on campus. So, we can use the evenings and weekends for practice. This time may also be con venient for typing our assignments, other than writing them.

Internet Speed

Another setback the participants mentioned was access to the Internet, which was sometimes very slow. They emphasized that the Internet was sometimes very slow even after connection. As a result, they wait for a long period of time to access web pages. They also noted that some of the computers in the ICT laboratory were not connected to the Internet, and it was difficult to learn how to use the Internet resources without a connection. One participant when asked if he was ready to use technology in teaching said:

> I don't think I am ready to use technology in my teaching. I don't want to embarrass myself in front of my students because students who come from privileged families know more about computers and how to use the Internet, than I think I do. Here (meaning at the college) we do very little on the Internet because it is slow. So, I think I will be embarrassed to be taught by my students how to search materials on the Internet.

Power Outages

The last reason participants cited was power outages, especially in summer. They said sometimes thunder and lightning cause severe power outages, and once there is power outage, they cannot use computers. They noted that, sometimes, the power outage can last for several hours before it is fixed, especially if it is not only a problem of STC but of the entire neighborhood. During the absence of power, they do not engage in any technology related activities in class, apart from a regular lecture. As a result, they miss a lot of material during the times when there is no power, especially in summer.

DISCUSSION AND CONCLUSION

Essentially, both quantitative and qualitative findings of this study revealed complementary results about pre-service teachers' perceptions of technology and using technology to support language teaching. In fact, the qualitative portion illuminated the *why* question that arose from the quantitative analysis. For instance, the mean for pre-service teachers' potential to use technology for language teaching was lower than that of their perceptions of its usefulness, suggesting pre-service teachers were less likely to use technology to support language teaching. The reasons pre-service teachers gave during the interviews when triangulated with the quantitative results complemented each other. Therefore, the challenges pre-service teachers encountered were related to the low ratings on their potential use of technology in the language classrooms.

Overall, the results can be explained in terms of pre-service teachers' low efficacy in using technology to teach ESL in comparison with the perceptions of its usefulness. The disparity between their perceptions of the usefulness of technology, together with the compromised intention to use it for language teaching is an epitome of a disconnection between the ICT program and its intended objective. As revealed by the qualitative section, the disparity is mainly caused by lack of confidence in using technology, arising from myriad challenges orchestrated by class size, practice time, Internet, and power outages that pre-service teachers encounter, leading to low efficacy. For instance, the large number of students in the ICT classes tends to slow the frequency of technical support students receive, and this, in turn, lowers their confidence levels associated with using technology to support teaching. There is no doubt that teachers need a lot of technical support in technology (Selami, 2013), and that support builds teachers' confidence in merging technology with their teaching practices (Redmond, Albion, & Maroulis, 2005).

Also, it is worth noting that in this study each of the groups (i.e., year 1 through year 3) reflected a different perception pattern with regard to integrating technology with language teaching. The decline by the third-year group between 30-39 years to use technology for teaching has a direct impact on the main objectives of the ICT program, which is to prepare pre-service teachers to integrate technology with their teaching. The third-year students between ages 30-39, as they were in their final year, must have developed a positive cognition of technology that translated to its potential integration with instruction. However, this was not the case in this study; instead, the group showed a decline. The cause of this decline may be attributed to the challenges the pre-service teachers cited in the qualitative section of this study, such as large classes, lack of practice, slow Internet, and power outages.

Overall, the challenges pre-service teachers encounter in developing countries on issues of technology compromise the adoption and integration of the same to the classrooms. As revealed by this study and, also, as observed by Jaffer, Ng'ambi, and Czerniewicz (2007), one of the challenges facing technology in Africa, including Swaziland, is having a large number of students in the classrooms, which makes it practically difficult for ICT instructors to support students in a timely manner. And if students do not get support quickly, they lose focus and interest in technology. However, besides the challenges facing the adoption of technology in Swaziland such as class size, practice time, Internet, and power outages, the importance of integrating technology with instruction in ESL cannot be underrated; thus, solving these challenges is crucial for education to thrive in Swaziland, including other similar ESL contexts. If these challenges are not mitigated, they continue to thwart all concerted efforts to integrate technology with instruction. Also, these challenges compromise the teacher's positions in executing their educational mandate, including the use of current educational metaphors. Teachers are crucial in effecting educational changes (Ertmer & Ottenbreit-Leftwich, 2010), and it is through effecting current educational metaphors that a 21st century ESL teacher can be validated.

As noted by Armstrong and Yetter-Vassot (1994); Blake (2000); Brett (1997), and Pusack and Otto (1990) learners benefit a lot when technology is incorporated into the classrooms. Therefore, beyond all these challenges, teachers have the responsibility to pave ways for new innovations in education, including integrating technology into the classrooms (Kim, 2002) in order to expose learners to a variety of materials that support learning (Montelongo & Herter, 2010). Thus, if these challenges are not mitigated, the attempt to improve education, especially teaching English as a second language using technology is threatened at its core, not only in Swaziland, but also in other ESL contexts with challenges similar to that faced by Swaziland.

CONCLUSION

The study examined the impact and cognition of technology on pre-service teachers of English in Swaziland, where English is taught as a second language (ESL). The lens through which this study examined the phenomena was the diffusion of innovations theory and the grounded theory. The results of this study revealed myriad challenges facing the adoption and integration of technology to support language instruction in Swaziland. These challenges can be mirrored in other ESL contexts. Therefore, this study serves as a springboard for more research on ways to improve the adoption and integration of technology to support instruction in ESL.

Also, this study can be used to inform policy makers and curriculum designers on critical issues revolving around the adoption of technology to support instruction in ESL. However, more empirical research must be conducted on a large scale, covering more teacher education institutions. For instance, this study did not collect data from a large sample size; therefore, expanding data collection to a large sample can unearth more challenges that this study did not establish, regarding the adoption and integration of technology with instruction in Swaziland.

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Characteristics of Today's Applied Engineering College-Level Educator

By Jeffrey M. Ulmer, Douglas Koch, and Troy Ollison

ABSTRACT

Higher education is constantly changing and evolving. Many contend that the recent changes have not always been positive and that current changes have greatly affected applied engineering programs. The purpose of this article is to investigate and collect information regarding current issues and the current state of educators in postsecondary, applied engineering/technology programs. It is a broad overarching approach with the intent of identifying the current state, potential research needs, and concerns within the discipline. Two hundred and twelve faculty members within the United States responded to a national survey to help fellow faculty determine the current and evolving characteristics of today's applied engineering college-level educator. Previous literature and data identifies changes related to financial challenges, salaries, technological advancement, professional experience, course load and class size, globalization, and lack of advancement opportunities. The survey sought to determine the current status of the field in those areas and found that the mean salary of $73,567 for the respondents was above the mean national higher education salaries but had a high standard deviation. Of the faculty, 74% are teaching in the classroom followed by 13% hybrid, and 13% online. The mean number of years of service outside of academia was 12.34. Regarding positional status and opportunities for advancement, the respondents were 21% contract only, 19% tenure track, and 60% tenured faculty. The data collected points out some areas that have potentially changed over time and areas that need further investigation. Long-term data is needed to establish a change in trends.

Keywords: Higher Education, Professional Development, Technology, Applied Engineering

INTRODUCTION

Most industries and businesses are in a constant state of change. As economies change, technologies evolve, and labor forces fluctuate, industries have to adapt and change as well. Higher education is no different. Some might argue that education, particularly postsecondary education, is somewhat slow and reluctant to change but it does change nonetheless.

This purpose of this article is to investigate and collect information regarding current issues and the current state of educators in postsecondary applied engineering/technology programs. It is a broad overarching approach with the intent of identifying the current state, potential research needs, and concerns within the discipline.

Review of previous literature and studies reveal that there are several aspects of applied engineering programs that are changing and are of concern to many of the current educators. A couple of the changes or concerns often pointed out include a potential shortage of well-prepared faculty and concerns of salary compression or low salaries. According to the Bureau of Labor Statistics (2010), postsecondary teacher growth is projected at 17% from 2010 to 2020, and in 2010 the faculty earned a median salary of $62,050 per year. Additional concerns include the ever- changing population of students and their skills and abilities they bring with them out of high school. Applied engineering college-level educators are being called upon to deliver remedial, introductory, intermediate, and advanced technical content to students in traditional classroom, hybrid/blended, and 100% online delivery methodologies. Many faculty members are not only teaching typical lecture courses but also being tasked with running student laboratories, advising students, participating in professional associations, serving on governance committees, having responsibility for finance, and keeping technical education for themselves, and their students, at a high level of competency (Chikasanda, Otrel-Cass, & Jones, 2010). The culmination of these factors may result in possible reasons for some educators to leave teaching. Steinke and Putnam (2011) pointed out that applied engineering educators leave the teaching profession due to "low salaries, lack of career advancement, or administrative support, student and peer issues, and other school and environment-related concerns" (p. 41). This paper is a culmination of efforts after a broad literature review-based survey was administered online to educators in the United States with the purpose of obtaining the current and evolving characteristics of today's applied engineering college-level educator.

CURRENT CHALLENGES FACING EDUCATORS

There are many challenges facing university faculty given the current systems and methodologies employed by higher education institutions. Some contend that certain changes within higher education are detrimental. Wheeler (2004) provided seven fundamental reasons for the decline of the traditional university system and the faculty in the system. They include "technological innovation, adverse economic climate, mounting commercial competition, demands for greater flexibility, subject proliferation, erosion of academic staff base and globalization" (p. 12). Wheeler also stated that the survival of universities is dependent upon retaining talented and innovative staff through job security, job satisfaction, and optimal rewards without using the typical disdain often given to faculty who support the academic system.

University faculty members are very resilient and have been forced to adapt to changes. Today's educators possess passion for their jobs and often focus on where they can make a difference (McClellan, 2012). In the midst of change, educators typically go with the flow and adapt to their educational reality (Osborn, 2012). With changing technologies and evolving delivery methods, faculty members have received the "do more for less" mentality from many higher education institutions. Privateer (1999) pointed out these concerns several years ago stating, "factoring in the growing tendency of federal officials, governors, legislators, governing boards, and college and university administrators to envision instructional technologies as a panacea able to maintain the status quo while dramatically cutting delivery costs" (p. 66).

Financial Challenges

According to Kelderman (2012), state appropriations for colleges declined 7.6% from 2011-2012. Program and departmental budgets are being stretched further as costs of operations are ever increasing. Numerous academic institutions are facing financial challenges and focusing on increasing enrollments to offset budget and appropriation deficits. Donoghue (2011) related that many colleges and universities are increasing the number of students in each class and the number of classes taught each semester by each educator. This translates into more generated revenues. Many administrators in higher education feel that the current state of academia can be remedied through higher levels of recruitment and retention of faculty (Field, 2011). Miller (2011) supported this idea by stating that marketing is a key to program success and survival. Currently, higher education faculty recruit and retain students through face-to-face meetings, web-based technologies, and social networks (Doggett & Lightner, 2010). Sevier (1996) stated years ago that higher education administrators begin with vision, define marketing broadly, create an institutional image, and understand student decision-making to set the stage for a increasing student enrollment and keeping retention higher.

Salaries

Salaries are often mentioned regarding concerns for retaining and attracting qualified faculty. Whereas postsecondary teachers earned a 2010 median salary of $62,050 per year with no requirement of related occupational experience, faculty in the more specialized area of career and technical education (technology and applied engineering teachers) earned a median salary of $53,920 per year with 1 to 5 years of related occupational experience (Bureau of Labor Statistics, 2012; Occupational Outlook Handbook, 2012). This disparity in salaries is a reality, and no literature could be found to explain the differences. The lower salary is exasperated by the fact that non-faculty feel that college educators do not earn the salary they currently are paid because faculty typically work less than one-half the time of those outside of academia (June, 2012). Furthermore, many institutions are on a faculty-hiring freeze, and faculty pay dropped 1.8% during a 2011-2012 academic year undergoing a 3% inflation rate as reported by the American Association of University Professors (June, 2012; Osborn, 2012).

Technological Advancement

Technologies have evolved to help educators maintain levels of competency and give students the tools they need for their studies. As these technologies have evolved, educators still face challenges in providing students with basic skill competencies all while increasing the number of postsecondary students in their programs, aligning curriculum with employers' skill needs, creating better education delivery modalities, and still attempting to provide students with an educational experience that adds to a student's skill sets (Jones, 2013).

One of Wheeler's (2004) reasons for the decline of the traditional university system was ironically technological innovation. One would think that technological innovation would be an asset that higher education relies on and benefits from; to some degree that is the case. Lack of technological innovation and competency can be a detriment. Grumwald (2010) summarized that effective teachers use technology to enhance student learning. The understanding of technology is a must for technologists and applied engineering college-level educators (Devine, 2006). Educators need to be ready to handle diversity, incorporate technology for faculty and student breadth-of-knowledge, use multimedia formats to aid critical thinking, and teach students entrepreneurial skills (Donlevy, 2005; Kenney, McGee, & Bhatnagar, 2012).

In the new reality of online education, an educator is someone who "reaches across time and distance through online courses and virtual universities" (Wolcott, 1997, p. 3). Key student program awareness tools and education technologies available for education institutions include: "virtual campus tours, online enrollment and admission, specialist keynote lectures via webcasting, individualized course delivery and live links to special events" (Wheeler, 2004, p. 11). Gumbo, Makgato, and Muller (2012) took the competency of educators seriously by suggesting that educators should be profiled to ascertain if their level of technology understanding is satisfactory, and if not, apply appropriate remedial training to prepare them for educating today's students.

Technical innovation also encompasses specific technologies within the field(s). According to a Society of Manufacturing Engineers (SME) survey with 261 respondents, conducted by Callahan, Jones, and Smith (2008), students should be prepared in areas of "lean process improvement tools, CAD/CAM, flexible manufacturing, integrated manufacturing systems, six sigma and automation" (p. 5). Therefore applied engineering educators should possess these same skills. Other areas of preparation for students, and educators, include: "sensor technology, advanced inspection techniques, automated material handling, expert systems, artificial intelligence, simulation, laser applications, design of experiments (DOE) and composite materials" (Callahan, Jones & Smith, 2008, p. 6).

Professional Experience

Garrison (2005) contended that an increasing number of universities strive to higher faculty members with industry or government experience. A quick search of job postings for applied engineering related positions will show many requiring or preferring recent industry experience. Applied engineering college-level educators often enter teaching straight out of the industrial trenches. Garrison found that the predominant reason for individuals to switch from industry to academia was "the desire to teach." These late-entries of "new" faculty, who have professional experience, often benefit the students due to their experience in applied engineering and technology. In 2010, Nickolich, Feldhaus, Cotton, Barrett, and Smallwood commented that midcareer professionals bring other attributes and stated:

> In addition to their presumed subject matter backgrounds in high-demand disciplines, midcareer professionals who are currently a part of, or choose to enter teaching, can bring new maturity and experience to the nation's talent base of educators and help connect teaching and learning to expanded applications in the world of work (p. 44).

One of the challenges of requiring work experience prior for faculty positions is that it reduces an already small pool of candidates. In some professions, advanced degrees are not often sought and may not always benefit someone in an industrial setting. An individual may have excellent work experience but may lack the required education or terminal degree required for many jobs in higher education.

Course Loads and Class Sizes

Donoghue (2011) stated that many universities are trying to offset financial deficits by increasing sections of course offerings and increasing the numbers of students enrolled in those sections. Faculty at one time were given release time to pursue scholarship, continuing education, and to offset large class sizes. Now they are often being required to increase their activities on committees, recruitment, and participation with accreditation activities or other duties. Wilson (2011) mentioned several examples in which release time and reduced teaching loads have been removed from faculty. She believes that release time and "deals" for teaching relief are not as common. She stated that, "the pendulum on granting special deals in exchange for service is swinging back, specifically at public research universities." Many universities are going to standard teaching loads and with the increased enrollments at many schools; class sizes are increasing as well.

According to Barwick (2007), when faculty members discuss workload, class size "arises repeatedly." Increasing the number of sections offered and the class size have many ramifications for faculty, departments, budgets, and the students. Faculty do not typically contend that student learning increases as class size increases. Many faculty are now teaching additional courses or sections to accommodate the increased need. As the number of students increases in classes, so do the costs associated with the classes. A typical lecture-based course will typically entail only an increase in workload for the faculty teaching the course, but many of the applied engineering and technology-based courses have lab and hands-on components. This creates increased needs for equipment and materials or could potentially pose a safety concern if numbers are too large.

Globalization

Wheeler (2004) also mentioned globalization as a cause for decline. Globalization is affecting how students should be educated (Ayokanmbi, 2011). Therefore technology educators should align course content with the needs of industry (Hogan, 2009; Jones, Smith, & Callahan, 2010). Demographic changes, technology advances, and globalization are claimed to be the game changers in the 21st century (Donlevy, 2005; Karoly & Panis, 2004). In fact, many educators are being encouraged to insist that their applied engineering students acquire global perspectives through exposure to cultures in other countries and to be prepared for mobile careers (Ayokanmbi, 2011).

Lack of Advancement Opportunities

Lack of opportunities for advancement or clearly outlined paths for advancement also seem to be a concern for faculty. Today's educator may or may not be tenured or in a tenure-track position. This all varies greatly with the type of institution and the mission of the institution. Although tenure-track faculty are usually assigned mentors to nurture scholarship and offer academic-pertinent advice toward tenure consideration, tenured faculty still require additional professionally applied training and education (Chronicle, 2012). According to "Midcareer Mentoring, Part 1," published in *The Chronicle of Higher Education* in 2012, professors have questions and concerns about post tenure. The top questions asked include:

1. How would I pursue employment at other institutions?
2. Can a counteroffer at my institution help improve my career?
3. How much service is required at my institution?
4. Should I choose a position in administration?

These top questions may hint at tenured faculty members' concerns and desires to seek additional employment, address low salaries, and continue professional growth.

Obtaining tenure and progression through the ranks (instructor-to-assistant professor, assistant professor-to-associate professor, and associate-to-full professor) requires a well-documented dossier and supporting materials in the area of teaching, scholarship, and service in many higher education institutions (Kelly, 2008).

According to the American Association of University Professors (1993), "we believe that all faculty members—regardless of institution and regardless of workload—should involve themselves as fully as possible in creative and self-renewing scholarly activities" (p. 198). Service in academia possesses a broad base of definitions ranging from service on committees to public service for organizations outside an educational institution (University of Wisconsin - Stout, 2010).

PURPOSE OF THE STUDY

The purpose of this study was three-fold for applied engineering college-level educators: 1.) conduct a broad literature review on employment conditions affecting faculty, 2.) administer a career-status-update survey to faculty in the United States, and 3.) report summarized survey results on the current and evolving characteristics in order to identify future, more in-depth research needs.

METHODOLOGY

A 23-question online survey was developed for distribution to faculty through the Association of Technology, Management, and Applied Engineering (ATMAE) and Texas A&M Engineering Technology (tamu.edu) Listservs at United States community colleges and universities that include Engineering Technology, Industrial Technology, or Technology programs. Information was obtained from faculty through an introductory listserv email and enclosed web link to the survey. The survey was posted in March of 2013. See Appendix A for the content of the online survey. Survey responses were kept confidential for this study.
Summarized survey data using Microsoft Excel and Minitab 16 were used to categorize:

- State of employment
- Positional status
- Faculty rank
- Length of time in current rank
- Length of time in a nonacademic position (before or after academia)
- Primary academic program for employment
- Number of students taught
- Academic salary
- Nonacademic salary
- Accreditation agencies supporting the program
- Degree levels obtainable for students
- Institutional offering of market pay
- Level of academic freedom
- Benefits cost of coverage
- Effective use of faculty talents
- Manageability of teaching requirements credit hours taught per semester
- Percent of share for class type (face-to-face, hybrid, online)
- Ease in getting resources for teaching and labs
- Level of expectations for research (scholarship)
- Unique ways in which the institution supports faculty beyond base contract salary
- Expectations for promotion and tenure and general comments related to the college/university
- Satisfaction level at your institution

Study limitations could exist due to information provided by survey respondents. For instance, faculty may not possess a comprehensive understanding of the actual reasons for the way in which their institution is managing academic affairs. Furthermore, low salaries or benefits could be to the result of poor faculty performance or discord present between the faculty member and the immediate chair or supervisor. Another potential limitation was the use of a researcher-developed instrument with limited validity and reliability.

SURVEY RESULTS

State Representation for Study

Two hundred and forty four people from 39 states (see Figure 1) provided survey data, although this number was reduced to 212 survey respondents after removing individuals who did not provide one of the following responses: 1.) The primary applied engineering-related program, 2.) State worked in, 3.) Faculty rank, 4.) Positional status, or 5.) Average academic salary. This action was taken because these five questions were the baseline for extraction of information for summarization for faculty.

Positional Status

Primary positional status for survey faculty consisted of contract only (21%), tenure track (19%), and tenured (60%).

Faculty Rank

The dispersion of faculty rank was: Coordinator (1%), Director (1%), Adjunct (2%), Lecturer (2%), Instructor (13%), Assistant Professor (16%), Associate Professor (36%) and Full Professor (29%).

Length of Time in Current Rank

The mean years of service for the respondents were 10 years. The range was from 1 year to 40 years, with a surprising number of respondents with less than 10 years of service (see Figure 2).

Length of Time in a Nonacademic Position

The respondents had varying lengths of service in nonacademic positions with a range of 0-50 years and a mean of 12.34 years (see Figure 3).

Primary Programs and Degree Levels

Faculty teach in the following programs (with greater than 5 responses for each item):

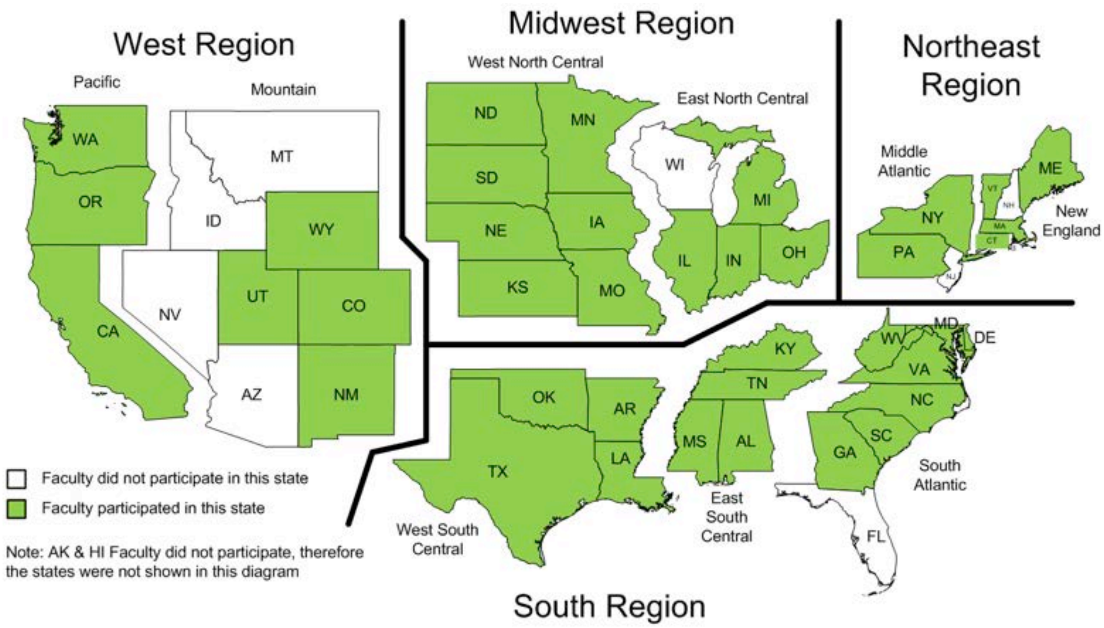

Figure 1. Survey participation by region, subregion, and state

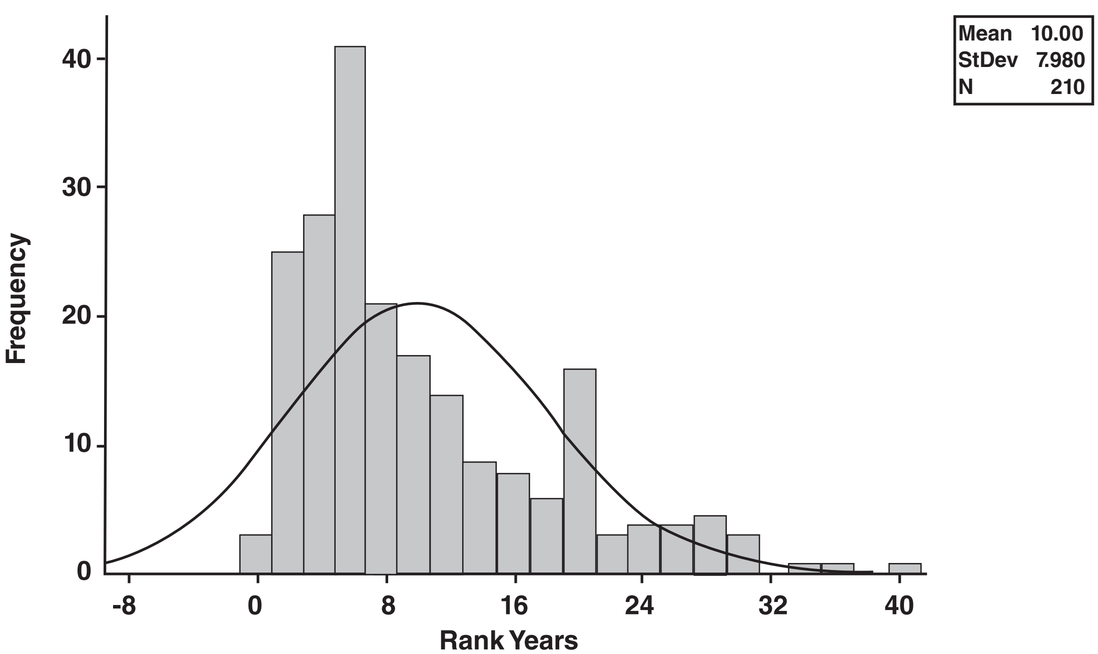

Figure 2. Faculty length of time in current rank

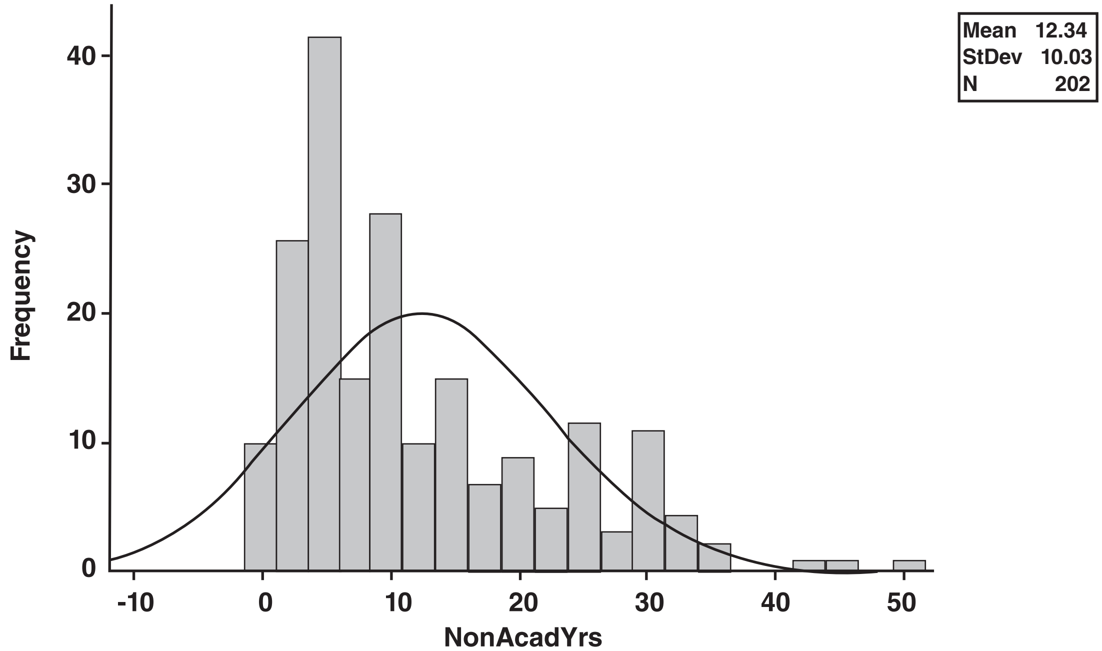

Figure 3. Faculty length of time in a nonacademic position

Construction Technology or Management (12), Design & Drafting Technology (or CADD) (12), Electronics Technology (33), Engineering Technology (76), Industrial Technology (15), Manufacturing Technology (13), Technology (7) and Technology Management (12). Degree levels taught as reported by greater than 10 survey respondents consisted of the following: Undergraduate (Associate—2 Year) (69 respondents), Undergraduate (Bachelor—4 Year) (94) and Graduate (Masters) (35).

Faculty Credit Load by Semester and Students per Semester

The number of credit hour load and students taught by a faculty member in a semester is provided in Figure 4. The mean credit hours taught per semester is 12.27 with an average of 63.86 students taught per semester.

Faculty Salary and Contract Length

Faculty salary mean was $73,567 with a standard deviation of $24,890 (see Figure 5). The vast majority of the faculty members are on a 9-month contract.

Administration Position and Pay

Survey respondents (number provided after title) who were both a faculty member and an administrator had the following primary positional titles: Chair (18), Coordinator (32), Department Head (3), Director (2), and Program Director (4). Seventy-one individuals responded to this question and provided the following stipend yearly amounts (values were only listed for greater than 3 responses): $0 (26 respondents), $3,000 (9) and $6,000 (4). Stipend range: $0 to $75,000 per year. Other means of support consisted of release time, teaching of summer courses, grant work, and online course development.

Market Pay

Yearly competitive (market pay) is not acknowledged or utilized at 50% of faculty institutions (83 respondents). The remaining 50% of respondents reported the following professional organizations for benchmarking: AAUP, ABET, ACCE, ASEE, ATMAE and CUPA-HR.

Accreditation Body

The primary accreditation body supporting a faculty member's primary program were (number of responses in parentheses): Accrediting Board for Engineering & Technology (ABET-EAC) (9); Accrediting Board for Engineering & Technology (ABET-

TAC) (94); American Council for Construction Education (ACCE); and the Association of Technology, Management, and Applied Engineering (ATMAE) (45).

Academic Freedom, Benefits Cost of Coverage, Talent Usage, and Teaching Manageability

Academic freedom scored a mean of 3.79 on a scale of 1 to 5, with 5 being the highest. Benefits cost of coverage scored a mean of 3.57. Similarly, faculty talent usage scored a mean of 3.52. Teaching assignment manageability scored 6.16 on a scale of 1 to 10, with 10 being the highest.

Teaching Method

Faculty taught by face-to-face (74%), hybrid (13%), and online (13%).

Resources and Support, and Research (Scholarship) Expectations

Resources and support provided for faculty rated 6.33 on a scale of 1 to 10, with 10 being the

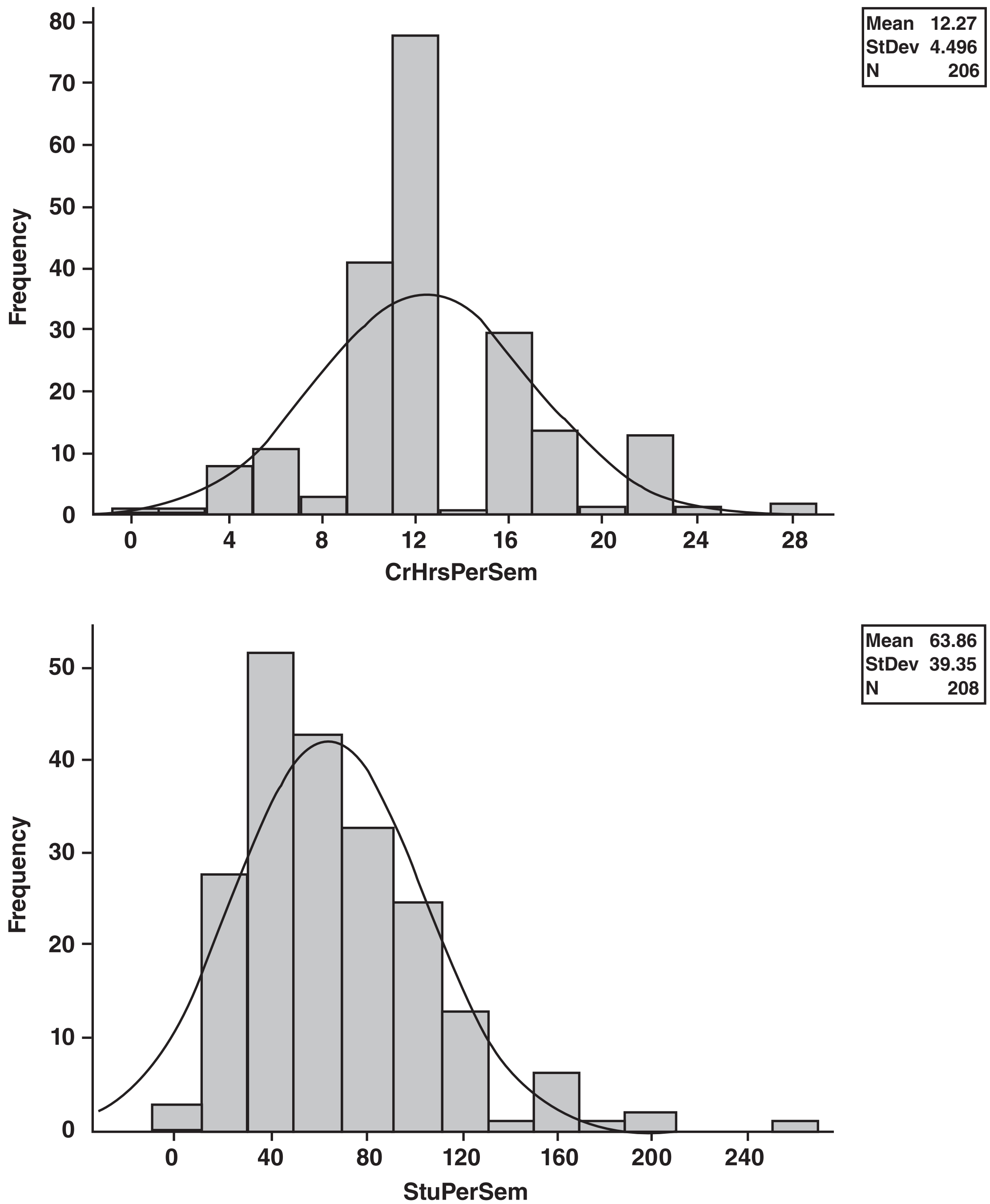

Figure 4. Number of students taught per semester by faculty

highest. Research (scholarship) expectations by educational institutions scored 2.87 on a scale of 1 to 5, with 5 being the highest, by faculty.

Promotion and Tenure Expectations

The survey allowed for open-ended responses regarding the respondent's university tenure and promotion procedures or expectations. A summary of faculty anecdotal information on their promotion and tenure is provided below:

- Two publications required per year
- Five years teaching and 15 hours of Master's credit to apply for assistant professor
- A joke. No new faculty mentoring. No feedback from administration on how well we are doing
- Absolutely ridiculous and highly arbitrary — even though there are written requirements
- Based strictly on education and years of service

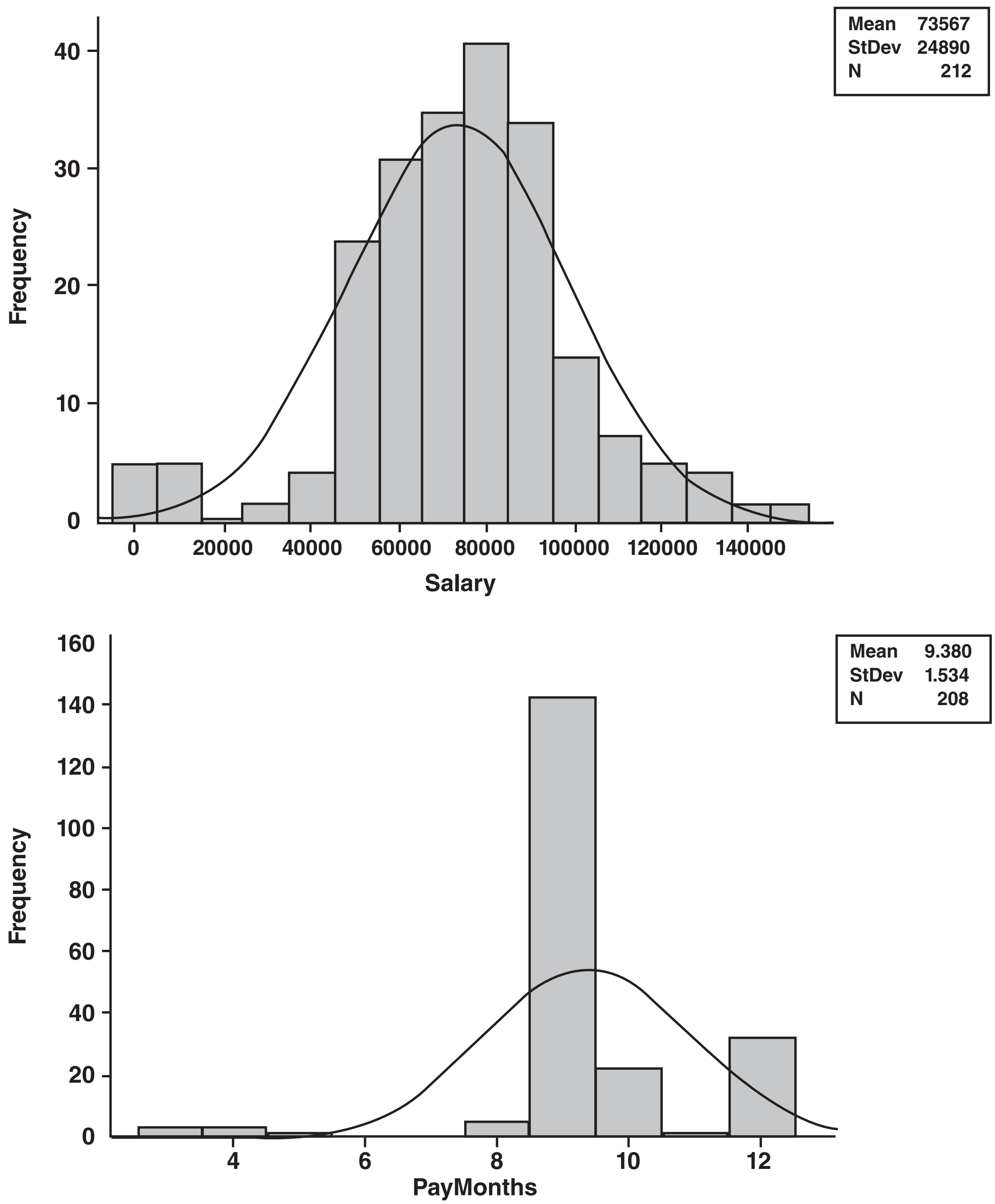

Figure 5. Faculty salary and contract length

- Does not hire full time but depends on adjuncts
- Expect too much scholarly activity given the teaching loads
- I will get tenure this year—the target is moving
- It is a fair system
- One is completely at the mercy of the academic politics

CONCLUSION AND DISCUSSION

The literature tended to focus on the areas of financial challenges, salaries, technological advancement, professional experience, course load and class size, globalization, and lack of advancement opportunities as some of the growing concerns in higher education. When examining and attempting to draw conclusions, additional longitudinal data will be needed to establish trends. The data collected from this initial study yields a current snapshot into the current standings. The researchers felt the response rate was appropriate and representative of the population. United States faculty representation by state was well represented with 39 out of 50 states responding (78%), which included 212 respondents.

From the standpoint of salaries, additional data will have to be examined to see trends, but the mean salaries reported were above the national higher education mean. The mean of $73,567 for faculty salary fits well within the normal distribution but the standard deviation of $24,890 is very wide—possibly due to positional status, rank, length of time at current rank, institution, location within the United States, and market pay. Faculty contracts are primarily 9 months; 12 months for a chair or administrator.

Technological changes have transformed education greatly. Online delivery of courses and materials was one of the areas most affected or actually created by technological advancement. Although online education is growing in the United States as shared by other scholarly articles, the evidence of 74% of faculty teaching in the classroom followed by 13% hybrid, and 13% online, seems to be a relatively small percentage, and further study is needed to see if it is increasing within applied engineering.

The vast majority of the respondents had some work experience outside of academia with a mean of 12.34 years. This could support the notion that applied engineering programs tend to hire individuals with professional experience. More information is needed to determine if this is a requirement and benefit within the field or it is typical that individuals pursue higher education positions after working in industry.

Course load and class size should be further examined, and additional information such as type of institution and its mission to draw usable conclusions. This information will also have to be examined longitudinally to determine changes and trends by institution type. The distribution of faculty credit hours per semester is not normally distributed. The mean of 12.27 credit hours is both the mean and the highest point in the curve. The right skew of the distribution for students taught per semester underscores the tide towards a larger number of students for each faculty member per semester.

The lack of advancement opportunities of faculty is a concern for many as a large percentage of positions are contract only with no opportunities for advancement. Positional status for faculty is interesting with 21% as contract only, 19% as tenure track, and tenured faculty at 60%. Per faculty responses in question 23, more colleges and universities are hiring more contract-only faculty. Also, it appears that faculty members have spent a lot of time in their current rank with a mean of 10 years. Promotion and tenure is a typical process of advancement and generated the most disparate and heated anecdotal responses by faculty. Some individuals were content with the P&T policy in force at their institution, whereas others were very upset on how promotions and tenure was discriminately given to "special" faculty.

Additional information was collected in other areas that may hint at satisfaction or provide more insight into changes within the field. Academic freedom, benefits cost of coverage, talent usage, teaching manageability, resources and support, and research (scholarship) expectations all scored from mid-level to approximately 80% of acceptability by faculty. Overall, it appears faculty were not overwhelmed by the working environment of their educational institutions; they were not too upset about it either.

FUTURE RESEARCH

The authors intend to conduct a statistical study on positional status; academic rank; length of time at current rank; length of time in a nonacademic position; and academic salary and market pay by state, region, and subregion. Through a descriptive and inductive analysis of raw data from this current study, it is hoped that an in-depth picture of exceptional career attributes can be extracted to help develop a "Faculty Body of Knowledge" in a future study. This study, as well as any planned future studies, is significant to college-level faculty and administrators in several ways. For administrators, being aware of current trends in higher education can be a powerful tool to manage and motivate faculty. From the faculty's point of view, this data can serve not only as negotiation leverage for compensation, load, and release issues, but it can also give faculty a sense of community by letting them know that their problems and concerns are not isolated and that they are potentially in the same situation as thousands of other faculty around the United States.

Trend data has to be established to determine change in the areas being investigated, and there are many areas in that warrant further investigation and refinement. These areas include: 1.) Additional analysis of administration faculty in terms of stipends and institutional expectations, 2.) Academic freedom in comparison to academic rank and other potential significant factors, 3.) Correlation between an institution's use of academic talents to manageability of teaching assignments, and 4.) Further analysis of teaching mode of delivery (face-to-face, hybrid, online), faculty resources availability, expectations for research (scholarship), unique ways to compensate faculty, and institutional expectations for promotion and tenure.

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Volume XL, Number 2, Fall 2014

History of the (Virtual) Worlds

By Steve Downey

ABSTRACT

Virtual worlds represent a small but dynamic sector of the computer technology field with global applications ranging from art and entertainment to online instructional delivery and educational research. Despite their worldwide acceptance and usage, few educators, researchers, or everyday gamers fully understand the history and evolution of virtual worlds – their genres, platforms, features, and affordances. Many of the innovations we readily recognize today (e.g., user creation of in-world objects in worlds like Second Life) began as grassroots efforts by gaming and computer enthusiasts who were long on passion but short on documentation. The end result is a twisted and often thorny history for a technology that now actively engages hundreds of millions of users worldwide and millions of users within education alone. This article synthesizes histories and definitions from virtual world developers, industry leaders, academic researchers, trade journals, and texts in order to form a coherent historical narrative of events that contributed to the evolution and shaping of the virtual worlds as we currently know and use them in education and society in general.

Keywords: virtual worlds, history, computer technology, evolution

INTRODUCTION

Virtual worlds represent a small but dynamic platform within the field of computer technology. A quick search of academic journals and respected Internet sources will demonstrate that there is a growing literature base addressing the application of virtual world environments for a variety of purposes, including educational research, the delivery of instructional courses and programs, community development, entertainment, and more. Within education, renowned institutions around the world have long been affiliated with virtual worlds (e.g., University of Essex, University of Illinois, and Carnegie Mellon University). In more recent years, Harvard University, Indiana University, and University of Wisconsin have led the way in educational research related to virtual worlds. However, for all of the growth and inroads virtual worlds have made into education and society at large, there are very few educators, researchers, and everyday gamers who understand how virtual worlds, their genres, platforms, features, and affordances have evolved over the decades to their current state. As virtual world pioneer, Richard Bartle, wrote on the 30th anniversary of the virtual world MUD (October 20, 2008), "Some old-timers know the history of MMOs and whence they came, but most of today's developers haven't a clue" (para. 5).

For demonstration purposes, the following is a short quiz; try it and see how you do. The answer key is at the end of this article.

1. In what year was the first virtual world created?
2. What was the first virtual world to enable its users to create in-world objects?
3. What is the connection between Luke Skywalker and virtual world avatars?
4. True/False: The word *dungeon* in the term *Multi-User Dungeon* is a reference to the Dungeons & Dragons game from which early virtual worlds drew inspiration.
5. Rank the popularity of the following virtual worlds from most to least popular, based upon total user accounts at the height of their popularity: Club Penguin, EverQuest, Habbo, Second Life, and World of Warcraft.

If you didn't get all five correct, don't feel bad. It's surprising how much virtual world literature cites conflicting dates, events, and definitions as being correct. For example, not everyone agrees which virtual world was created first – see the section on First Generation Worlds for the varying views. To better understand this area of technology and how its evolution has established and supported a variety of teaching, learning, and socialization affordances taken for granted nowadays, this article synthesizes histories and definitions from virtual world developers, industry leaders, academic researchers, trade journals, and texts in order to form a coherent historical narrative of events that contributed to the shaping of the field as we currently know it.

PROBLEM BACKGROUND

Brought to the attention of mainstream education and society in the mid-2000s through commercial successes such as World of Warcraft and Second Life, virtual worlds represent one of the fastest growing segments of the gaming industry during the first decade of this century (Dafferner, Chan, & Valette, 2010; International Business Times, 2010). The history of virtual worlds, however, stretches back more than 35 years and was slow to develop during its first few decades. Similarly, literature from the early days is comparatively sparse and much of the documentation from this period in virtual world history (e.g., magazine articles, user manuals, software code) is slowly disappearing (Koster, 2009).

Only during the last 10 years, driven by the rise in popularity of computer games, has there been a rapid increase in publications related to virtual world environments. This recent literature, however, is largely fragmented and widely dispersed across a variety of disciplines – for example, computer science, education, sociology, anthropology, and communication, (Downey, 2012). Although this can be good in that it demonstrates an examination of the field from different perspectives, it also produces a significant challenge to people entering the field as they typically gain only a partial understanding of the domain and its history.

A lack of a coherent history is not the only problem stemming from the fragmented literature. To date, no common agreement exists for defining or even naming these virtual spaces (Bell, 2008; Downey, 2010; Schroeder, 2008). They are interchangeably called massively multiplayer online games (MMOGs), massively multiplayer online role playing games (MMORPGs), multi-user virtual environments (MUVEs), persistent worlds, synthetic worlds, virtual environments, and virtual worlds (Bartle, 2003; Bell, 2008; Combs, 2004; Damer, 2006; Doppke, Heimberger, & Wolf, 1998; Spence, 2008). In some cases, these labels reflect meaningful, albeit subtle, differences in the various types of environments. For example, MMORPGs and MUVEs are meaningfully different in their purposes, social rules, and so on; however, they are both large-scale, multi-person, virtual spaces. Recognizing both the commonality and nuance differences between these different environments, the umbrella term of *virtual worlds* is used in this article to broadly refer to all of these environments and their shared history.

Purpose, Target, and Scope

To address some of the challenges brought about by fragmented literature bases and an unstable lexicon, this article seeks to synthesize and clarify key definitions and historical information in order to aid others in extending their understanding of virtual worlds. In fulfilling this purpose, the content in this article revolves around two primary research questions: (a) what are the major milestones in virtual worlds history and (b) how have virtual worlds evolved from one generation to the next to reach the highly social and collaborative spaces we know today?

In reporting the major milestones of virtual worlds, the scope of this article is simply to identify what happened, when it happened, and how it affected later events in the evolution of virtual worlds. This article does not attempt to interpret these events through the lenses of different disciplines – for example, through anthropology: Boellstorff (2008), psychology: Turkle (2008), or others. It does, however, provide a linear timeline of the major events – many of which still influence the design, operation, and usage of virtual worlds today.

Given the summative nature of this article, the target audience for its contents is individuals who are new to virtual worlds. This article will aid them in gaining a chronological overview of the evolution of these worlds and a working definition of what currently constitutes a virtual world, from which they could continue their work within their own specialized disciplines and perspectives related to virtual worlds.

Methods

In completing this research, a historical research methodology was employed (Rowlinson, 2005; Johnson & Christensen, 2008). This approach utilizes four stages: (a) formulate problems to be addressed in the historical review, (b) collect data and literature, (c) evaluate materials, and (d) synthesize data and report findings.

The formulating of problems for this review is straightforward. Virtual worlds have a fragmented history due to poor and disappearing documentation; they also have poorly defined terminology and are not well understood conceptually . To address these problems, materials were collected and analyzed with separate but related objectives in mind: (a) generate a formal working definition of what constitutes a virtual world and (b) delineate a timeline of major milestones in the evolution of virtual worlds.

For stage two, the collection of materials included both primary and secondary sources of information. Primary sources have direct involvement with the event being investigated, such as an original map or an interview with the person who experienced the event (Gall, Gall, & Borg, 2007; Rowlinson, 2005). In this article, these included information emanating directly from a world's developer, such as articles, blogs, presentations, and so on. Secondary sources are artifacts emanating from sources other than those having first-hand experience with the event. These sources include articles by academics and individuals not directly involved in the world's development (e.g., research journal articles), blogs of industry experts and academics (e.g., Terra Nova), news stories, game/world reviews, critiques, and others.

When evaluating materials, as was done in stage three, we considered Rowlinson's words: "Historians often use three heuristics in handling evidence to establish its authenticity or accuracy: corroborations, sourcing, and contextualization" (Rowlinson, 2005, p. 298). *Corroboration* involves cross-checking of statements, dates, and other information within a document (i.e., internal criticism) with other external sources and documents (Gall, Gall, & Borg, 2007; Johnson & Christensen, 2008). Sourcing relates to the authentication (or "external criticism") of documents and artifacts as a whole (Gall, Gall, & Borg, 2007; Johnson & Christensen, 2008). *Contextualization* is determining where and when an event took place. In this article, most of the evaluation work pertained to corroboration of developer claims (e.g., which virtual world came first). Contextualization was of lesser evaluative importance given the scope of this article; however, when possible, the author tried to acknowledge originating institutions where games/worlds were developed (e.g., Essex University for MUD1).

The final stage of data synthesis and reporting involved three major elements: selecting, organizing, and analyzing (Rowlinson, 2005). Selecting draws upon the evaluation process in stage three, above, to identify and select the most authentic and accurate information to include in the reporting (Johnson & Christensen, 2008). Organizing addresses how selected information is arranged to form a cohesive whole. Finally, analyzing relates to critiquing (and frequent re-evaluation) of findings as they related to one another to assess the overall accuracy and continuity of the information being reported.

Limitations

As with all studies, there are limitations associated with this research. In particular, three limitations affect the scope and potential quality of the findings presented in this article. First, only games/worlds that conformed to the formal definition presented in this article were selected in stage four for inclusion in the historical review. As a result, precursors and ancillary inspirations are omitted, for example, the original tabletop version of Dungeons & Dragons and novels such as Snow Crash (Stevenson, 1992). These exclusions were necessary to focus attention on the digital environments themselves, their traits, the terminology, and the conceptual heritage associated with these environments.

The second limitation is the lack of primary source documents and artifacts. Virtual worlds emerged as a grass-roots movement by enthusiasts, who often worked informally on a world in their free time. As a result, few of the early worlds were developed with any formal documentation and very little of that documentation still remains publicly accessible today.   Similarly, virtual worlds of the current generation typically are developed by for-profit, corporations (e.g., Sony, Blizzard, Electronic Arts) and do not readily publicize many of the innovations associated with their worlds in order to retain a competitive advantage.

The final limitation is a product of the second. Due to the lack of primary source documents and artifacts, information must be acquired from secondary sources (blogs, wikis, new reports, etc.) that may be biased, inaccurate, or purely personal opinion – even if they are statements from highly credible sources. Consequently, some findings may be omitted from the review because they couldn't be confirmed by additional sources.

VIRTUAL WORLDS THROUGH THE AGES: MAJOR MILESTONES

General agreement can be found in the literature that virtual worlds began during the 1970s (Bartle, 2004; Damer, 2008a; Kent, 2003; Koster, 2002; Mulligan, 2000); the exact date depends on whom you ask. The following narrative highlights prominent contributors to the three generations of virtual worlds and how their milestone contributions affected future worlds.

The three generations of virtual worlds defined in this article are based upon the changing nature and traits of worlds from one generation to the next (see Figure 1). First generation virtual worlds were primarily text-based, small in scale (250 users or less), and set in the realm of fantasy adventure (e.g., Dungeons & Dragons and Middle Earth). Second generation worlds witnessed the growing use of graphical worlds, larger scale systems (1,000 or more users), the introduction of social-oriented worlds, and the development of worlds in which users could create objects and shape their world in real time. Finally, the third (current) generation marks the age of massive systems (10,000+ simultaneous users), visually striking 3D worlds, and a growing array of genres and types of virtual worlds (e.g., MMOGs, MUVEs, MMOLEs; fantasy, science fiction, pseudo-reality) that target adults and children alike.

First Generation Virtual Worlds (1978 – 1984)

In reviewing numerous articles, dissertations, blogs, wikis, news stories, and other artifacts, no documentation was found that anyone intentionally set out to create the virtual world genre. This genre emerged through grass-root activities comprised of a series of one-step improvements, borrowed ideas, and ad hoc creations by computer enthusiasts who also were fantasy game hobbyists. Many of the early environments were just multiplayer versions of existing single player games. Given that many of these early worlds were developed either for fun and/or as personal challenges (Bartle, 2004), there is little documentation on these environments to ascertain which was truly the first virtual world. The literature points to multiple environments as being the "first" virtual world – Maze Wars (Damer, 2008a), MUD (Bartle, 2004, 2006; Kent, 2003; Ondrejka, 2008), Avatar (Call, 2010), and Habitat (Sharkey, 2009), among others. Each of these was innovative in its day and contributed to defining what we now think of as virtual worlds. As such, they all are discussed in the narrative that follows. However, MUD spawned a line of successors that can be traced to today's generation of virtual worlds (Bartle, 2006; Keegan, 2003; Mud Genealogy Project, 2005), thereby making it the digital equivalent of Ardi – the oldest known human fossil (Shreeve, 2009).

First Generation	Second Generation	Third Generation
Persistence	Persistence	Persistence
Small-scale systems	Larger scale systems	Massive scale worlds
Text-based displays	Graphical displays	Striking 3D presentation
Fantasy-based games	Games & social worlds	Games, social, & edu worlds
	Avatars (in-world persona)	Highly customizable avatars
	User control over objects	User driven communities
		Adult & child user bases
1978 – 1984	**1985 – 1996**	**1997 - present**

Figure 1. Generational Traits of Virtual Worlds. This figure presents a summary comparison of the prominent traits associated with each generation of virtual worlds.

Multi-User Dungeon or MUD was written by Roy Trubshaw in the fall of 1978 at the University of Essex (Bartle, 1990). Sometimes referred to as MUD1 to denote the first widespread release of the MUD system, MUD1 was actually the third iteration of the game that was started by Trubshaw and finished by Richard Bartle in 1979 (Bartle, 1990, 2004). Often mistakenly associated with the widely popular Dungeons & Dragons fantasy game, Bartle stated that the "D" in MUD does stand for "dungeon," but it does not relate to the game published by Gary Gygax and Dave Arneson in 1974 (Bartle, 2004). Trubshaw was inspired by ADVENT (aka Adventure, by Will Crowther and Don Woods) and ZORK (by Tim Anderson, Marc Blank, Bruce Daniels, and Dave Lebling at the Massachusetts Institute of Technology); he wanted to create a multiplayer version of those games (Bartle, 2004). The particular version of ZORK that Trubshaw played had been ported to Fortran and named "DUNGEN" [sic]. As a result, the acronym MUD (Multi-User Dungeon) readily presented itself and was adopted.

MUD1's contribution to virtual world history is nearly immeasurable. First and foremost, MUD1 demonstrated that users could share space, interact, and work toward a common goal, just as they had enthusiastically done in tabletop versions of games like Dungeons & Dragons. Numerous virtual worlds can trace their lineage back to MUD1 (Doppke, Heimberger, & Wolf, 1998; Keegan, 2003; Mud Genealogy Project, 2005). Examples of this can be seen in second generation worlds (described below), where MUD1 inspired TinyMUD, which lead to TinyMUCK, which lead to MOO, which lead to LambdaMOO, and so forth. As a result of this type of propagation, by 1992 there were more than 170 different multi-user games on Internet, using 19 different world-building languages (Rheingold, 1993). Witnessing this potential, computer programmers, university students, and hobbyists set about creating their own versions of a MUD, and the genre was born.

For the purpose of presenting both sides of the "*which virtual world was first*" argument, next is a quick note about Maze War (or Maze as it is sometimes known). Maze War was released in 1974 and was innovative in multiple ways; however, even though it supported multiple players (up to 8) it is not a virtual world – it lacks persistence among other elements. Conversely, it was one of, if not the first, networked first-person shooter games (DigiBarn, 2004). Also, its use of graphics gave the illusion of a 3D space, something not seen in virtual worlds until Avatar in 1979. Even though it is not a virtual world based upon the definition used in this article, Maze War is still noteworthy because it utilized instant messaging, non-player bots, and levels of play—all of which are features commonplace in virtual worlds today.

Avatar (developed by Bruce Maggs, Andrew Shapira, and David Sides at the University of Illinois) was released for the PLATO system in 1979. According to Bartle (2004) and Goldberg (1996), it was the first fully functional graphical world. It should be noted, however, unlike Habitat (see second generation, below) Avatar's graphics only utilized a small portion of the user's screen; static text and a chat interface consumed the remainder. Although Avatar was remarkable in several ways (e.g., it introduced the practice of "spawning" to repopulate monster/bots), it is the ease of player communication and use of group-oriented content that significantly advanced the practice of in-world collaboration. In doing so, it prompted other developers to create more in-world interactions and social elements in their worlds.

Second Generation Virtual Worlds (1985 - 1996)

A relatively quiet period in terms of commercial successes, the second generation was critical to the rapid growth witnessed during the current third generation. During the second generation developers learned valuable lessons about players' styles and tolerances, refined underlying technologies, and developed new business models for today's marketplace. Noteworthy worlds during this generation include Habitat, TinyMUD, TinyMuck, and Meridian59 – all of which are discussed next.

Habitat was a remarkable world developed by Randy Farmer and Chip Morningstar at LucasArts. Released in 1985, it marked the start of the second generation. It was the first world to employ the use of an avatar to establish a user's in-world presence (Morningstar & Farmer, 1991). Unlike first generation worlds, Habitat scaled well, supporting more than 20,000 users (Morningstar & Farmer, 1991). It also offered more in-world player interaction activities than the hack-n-slash dungeons of the first generation. Given its highly interpersonal nature (Farmer, 2003), Habitat arguably served as the first social-oriented virtual world (Damer, 2008a).

In 1989, *TinyMUD*, developed by Jim Aspnes at Carnegie Mellon University, was released. TinyMUD was innovative in that it focused less on combat and more on user cooperation and social interaction (Stewart, 2000). Its social focus and the fact that TinyMUD ran on widely popular Unix systems propelled the growth of TinyMUD, and MUDs in general, around the world. TinyMUD also spurred a series of innovations that Second Life users would find commonplace. For example, TinyMUD allowed users to create objects from within the virtual world (Doppke, Heimberger, & Wolf, 1998).

After playing TinyMUD, Stephen White (University of Waterloo) wrote his own variation, *TinyMUCK* (released in 1990), which further extended the functionality of TinyMUD and eventually created "MOO" (Bartle, 2004). MOO (MUD Object Oriented) provided a robust scripting language that allowed users to create in-world objects for social-oriented virtual worlds. Paul Curtis came along shortly thereafter and created LambdaMOO (Curtis, 1997), which gained popularity in the press and education.

As a result of these innovations, two distinct genres of virtual worlds emerged: game-oriented worlds and social-oriented worlds. Virtual worlds were no longer combat-driven realms in which players sought to get the upper hand on their peers. Thanks to customizable and cooperation-supporting venues such as Habitat, TinyMUD and LamdaMOO, virtual worlds began employing cooperative models of play versus purely player vs. player model (Jones, 2003).

Meridian59 (released in 1996) marked the end of the second generation and the beginning of the third. It was designed for slower 14.400 modems, but it began incorporating play styles and 3D perspective graphics found in today's worlds. It also was the first commercial game to use the new business model of directly employing the Internet, versus a proprietary network like CompuServe or AOL, to provide player access (Kent 2003). This model would become a common business practice for the highly profitable worlds of the third generation.

Third Generation Virtual Worlds (1997 – present)

The third generation of virtual worlds experienced an explosion of user growth and the entry of virtual worlds into mainstream society. No longer developed on shoestring budgets, third generation worlds have seen budgets from a few million dollars (Ondrejka, 2008) to hundreds of millions of dollars (Morris, 2012). They capitalize upon, and in some cases push the limits of, the increasing computational and graphic-rendering power of today's home computers in order to produce rich, vibrant visual worlds that draw users into the game and feed their desire to explore and play.

As much as Meridian59 was a stepping stone toward this success, Ultima Online (UO) was the first to begin realizing the enormous potential of virtual world games. Released in 1997 by Origin System Inc. (Electronic Arts), UO was designed from the beginning to be a richer and deeper world in terms of content than previous MUDs and worlds. In a recent interview (Olivetti, 2010), Richard Garriott, creator of the Ultima lines of games, explained that UO was intentionally designed to be different:

> [A] vast majority of MMOs are about running around, killing monsters and collecting treasure. They're not about interacting with the physical world in detail. Ultima Online was about this. Things such as placing cups and plates and silverware on tables, and being able to pick up rings off the ground were important to me. (para. 8)

The end result was that UO brought about a firestorm of changes in virtual world design. For example, different playing styles were accommodated (e.g., casual vs. hard core gamer) and first- person graphical views were used instead of the normal overhead view.

EverQuest, released by Sony Online Entertainment in 1999, served as the de facto standard for graphical virtual worlds during the early 2000s. Within six months of its release, it overtook UO in total subscribers and maintained the leading market share in the United States until 2005 (Woodcock, 2008). In EverQuest, casual players no longer had to fight for their lives as they did in UO's player vs. player format. This made it even easier and more enjoyable for newbies to join their friends online.

Further, EverQuest was designed to encourage group play, prompting players to get their friends online and in-world. Witnessing the rapid success of both Ultima Online and EverQuest, more than 100 graphical virtual worlds were developed during 2000-2001 (Bartle, 2004). Each of them tried to capitalize upon the growing market defined by these worlds.

To date, the king of all virtual worlds (in terms of revenue generation) is Blizzard's World of Warcraft (WoW). Released on November 23, 2004, WoW sold 240,000 copies overnight – more than any other game in history (Van Autrijve, 2004). While at their heights, EverQuest and Ultima Online reached over 300,000 and 230,000 subscribed users, respectively (Bartle, 2004; Woodcock, 2008). WoW, in turn, reached more than 11 million subscribers around the world (Blizzard, 2008) and held more than a 50% market share among subscription-based MMOGs for more than four years (Woodcock, 2008).

Building on the lessons learned from Ultima Online and EverQuest before it, Blizzard designed World of Warcraft for multiple playing styles; then it went further. Blizzard designed content for multiple age groups, including pre-teens through retirees – market segments that previously received little attention. In addition, they made game play for each of these different age ranges and playing styles fun from the beginning. "World of Warcraft was one of the very first MMOs that you could hop right into and have fun – right away" writes Michael Zinke (2008, para. 6), lead contributor for Massively.com. He also to stated that, "In the original EverQuest, at launch, you spent long minutes waiting for your character's health to regenerate after every fight. Spellcasters had to meditate, essentially vulnerable to everything in the gameworld, for even longer minutes to get mana back" (para. 9). All of this downtime left the non-hardcore gamer bored and unengaged.

In addition, well-scripted scenarios also aided novice gamers in getting their avatars up and going. In doing so, players felt an immediate direction and purpose as well as experiencing early successes as they are learning to play. Open-ended end-game features and dungeons designed for both small and large groups also were contributing factors to its success. With open-ended end-game play, once your avatar reaches the highest level of experience within WoW, there are numerous options for continued play – achievements, guild building, player vs. player rankings, and so forth. In addition, small group and large group dungeons allow users to select content suited to their social preferences. Small group dungeons (5 or 10 person) are shorter in length and are easier to find willing participants to join the group. Large group dungeons (20 or 40 persons) are highly difficult and require a great deal of social organization and reliance upon others in order to successfully complete a dungeon. These features along with WoW's artistic presentation and articulate storylines have made World of Warcraft the leading example for how to design engaging, easy-to-play, content-rich worlds that are suitable for a variety of age ranges and playing styles.

Picking up where the MOOs of the second generation left off, Second Life differs from the previous milestone makers of Ultima Online, EverQuest, and World of Warcraft in that its content is user-created. Although it is not the largest social-oriented virtual world, Second Life (launched in 2003 by Linden Labs) is one of the most well known due to its popularity with the media and education.

Due to the ease of in-world object creation and a culture of sharing and collaboration (Luban, 2008), Second Life users have created a wide array of content from realistic replications of real-world buildings and towns to highly imaginative fantasies to scientifically based simulations. In addition, breaking established rules used by most virtual world games, Second Life not only allows but often encourages its users to sell and exchange items through forums and auction houses like eBay (Ondrejka, 2004). This approach has continued to feed the Second Life economy with more than $160 million in user-to-user transactions in the first quarter of 2010, a 30% increase of the previous year (Caoili, 2010). Given its open format for creating virtually anything a user wishes in-world, Second Life remains a highly popular venue for educators wishing to establish a virtual world presence for their institutions or who want to take their students on a virtual field trip to the ancient days of Rome or to role play the part of the characters in a literary epic.

THE DAWN OF A NEW AGE?

Recent changes in the virtual world field during the past five years have signaled the possible beginning of a new age. Changing trends in user profiles, business models, and the introduction of reality-augmented virtual world platforms (e.g., Activision/Blizzard's Skylanders and Disney's Infinity) may serve as precursors for new worlds and platforms yet to emerge.

The earliest of these signs was the emergence of the pre-teen demographic segment among virtual world players. *Habbo* is one of the oldest (launched in 2001 by Sulake Corp, Finland) and most successful of the worlds to target this rapidly emerging market segment. A pioneer in kid-oriented virtual worlds, Habbo boasts 15 million unique users from 150 different countries (Caoili, 2010). Habbo provides its users with furniture, pets, and other accessories to build their own spaces and customize their play; the rest users create. Lead designer, Sulka Haro states:

> One of the key things is that practically all the content on the servers is created by the players themselves, so it's not like we have to do that much to keep up with the times if you look at the content itself, because it's the players bringing the stuff in (Sheffield, 2009, para. 31).

Even more interesting is that Habbo, like many kid worlds, has a nearly 50/50 girl/boy demographic balance (Nutt, 2007); this is particularly noteworthy given that virtual worlds historically are male-dominated venues.

In addition to early forerunners like Habbo, the entrance of international conglomerate and teen/pre-teen media heavyweight, Disney, into the virtual world scene caused shockwaves when it spent $350 million to acquire the kid-oriented world, Club Penguin (Barnes, 2010). In addition Disney has spent millions more creating new worlds targeting teens/pre-teens, such as ToonTown, Pirates of the Caribbean, and Pixie Hollow. Although not massive commercial successes, these worlds marked Disney's commitment to expanding the presence of virtual worlds to the teen/pre-teen demographic. In January of 2013, Disney announced a new gaming platform, Infinity (released in August, 2013), that integrates real world toys with virtual world style environments (Ha, 2013). Within the Infinity platform, kids and parents alike are given the ability to create their own virtual world spaces and incorporate their favorite Disney movie characters into these spaces – effectively creating a "virtual toy box" to create and share with their friends (Gaudiosi, 2013). Together with the Skylanders platform (pioneered in 2011 by Activision), these new environments are blurring the lines between real worlds and virtual worlds.

In addition to creation of new virtual world platforms, a new business model "Free-to-Play" (F2P) has emerged in recent years. This new model was devised in direct competition to the subscription-based model used so successfully by WoW, UO, and EQ. The end result has been the erosion of subscription rates of established games as users opt for smaller but less expensive virtual worlds. As a case in point, WoW's subscriptions have fallen from a high of 12 million in 2010 (Holisky, 2012; Kain, 2013) to 7.7 million in 2013 (Kain, 2013).

It remains to be seen if a new age in virtual worlds has truly emerged; if the history of virtual worlds has taught us anything, it is that change is constant and inevitable.

SUMMARY

While the popularity of virtual worlds in education and society has risen rapidly in recent years, the history of virtual worlds, themselves, can be traced to more than 35 years ago. Unfortunately their ill-defined history has left many educators, researchers, and everyday users partially informed and often confused about terminology and the evolution of these worlds.

The historical review in this article should help researchers and practitioners better delineate and understand the field, its history, and its potential future. In doing so, participants in virtual worlds — whether active gamers, content developers, researchers, students, and/or teachers — can gain a greater understanding of the chronological history and conceptual heritage of virtual worlds. With a colorful and diverse heritage, the history of virtual worlds will continue to grow as new worlds emerge and new applications of these worlds are devised.

GLOSSARIES

Terminology Associated with Genres

Virtual World	Generic, overarching term used to describe online environments (text or graphical) in which users collaborate communicate for the purpose of gaming and/or socializing.
MMO	Massively Multiplayers Online. A generic term like virtual worlds used to describe a spectrum of worlds.
MMOG	Massively Multiplayers Online Game. A subset of MMOs specifically oriented towards gaming.
MMORPG	Massively Multiplayers Online Role Playing Game. A subset of MMOGs specifically oriented towards role playing games such as World of Warcraft.
MUVE	Multi-User Virtual Environment. A term promoted by Harvard researcher Chris Dede to designate virtual worlds that are social oriented versus gaming oriented.

Names and Descriptions of Influential Worlds

First Generation Worlds (1978-1984)

Avatar	Introduced the practice of “spawning” (e.g., re-populating a world with monsters/characters) and facilitated players’ communications to be more collaborative.
Maze Wars	Multiplayer environment incorporating wireframe graphics, giving the illusion of a 3D maze in which players interacted.
MUD (aka MUD1)	Multi-User Dungeon, arguably the first virtual world; initiated by Roy Trubshaw and finished by Richard Bartle in 1979.

Second Generation Worlds (1985-1996)

Habitat	Technology Experience
Meridian59	First commercial game to directly employing the Internet versus proprietary networks like CompuServe or AOL.
MOO	MUD Object Oriented provided a robust scripting language that allowed users to create in-world objects for social-oriented worlds.
TinyMUCK	First world to allow users to create objects from within the virtual world.
TinyMUD	One of the first worlds to focus on social interactions versus gaming and combat; in doing so, it promoted a new genre of virtual worlds.

EverQuest	Designed to encourage group play, EverQuest stood at the de facto standard in virtual worlds prior to the arrival of World of Warcraft.
Habbo	The most popular virtual world, in terms of user accounts created, although it hasn't become the cash cow that World of Warcraft was.
Second Life	Highly popular world, especially in the education arena, due to its extremely diverse content and ability for users to create and collaborate together on projects, activities, and lessons.
Ultima Online	Ushered in the third generation of worlds by introducing a wide array of changes in virtual world design, including variable playing styles (e.g., casual vs. hard-core gamer) and new graphical views versus the traditional overhead view.
World of Warcraft	Due to its eye-catching graphics and numerous gaming innovations, World of Warcraft captured 50% market share among subscription-based MMOGs for more than four years, making it the most commercially successful virtual world to date.

ANSWER KEY FOR QUIZ

1. In 1978, Roy Trubshaw created MUD, Multi-User Dungeon. MUD inspired a series of subsequent worlds traceable to today's highly diverse array of social and gaming virtual worlds.
2. TinyMUD, created in 1989 by Jim Aspnes, enabled users to create in-world objects.
3. George Lucas. In 1977, Luke Skywalker hit the movie screens in the original Star Wars film by George Lucas. In 1985, LucasArts released Habitat, which was the first world to employ the use of an avatar to represent a user in-world.
4. False. The "dungeon" in MUD was a reference to a FORTRAN version of the game ZORK entitled "DUNGEN" and not a reference to the popular tabletop game Dungeons & Dragons.
5. According to market research by K-Zero (2013) and press releases from game manufacturers, at the height of their popularity Habbo was the most popular, followed by Club Penguin, World of Warcraft, Second Life, and EverQuest respectively.

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Technological Literacy Courses in Pre-Service Teacher Education

By By Roger Skophammer and Philip A. Reed

ABSTRACT

The goal of this study was to determine to what extent technological literacy courses were required in K-12 teacher education. A documents review of the appropriate course catalogs for initial teacher preparation was conducted. The documents review identified general education requirements and options for technological literacy courses, as well as requirements and options for these courses for English, social studies, mathematics, and science education majors. For this study, technological literacy was defined as "the ability to use, manage, assess, and understand technology" (ITEA, 2000/2002/2007, p. 9). This definition of literacy is broader than technology literacy associated with computer use and instructional technology, as well as courses limited to the history or philosophy of technology. A finding from this study is that there is very little exposure to technological literacy courses for prospective K-12 teachers. This may be due in part to the confusion between instructional technology literacy and technological literacy.

Keywords: Technological Literacy, Technology Education, Teacher Education

INTRODUCTION

The increasing rate of technological change in the United States requires a technologically literate populace that can think critically and make informed decisions about technological developments. The International Technology and Engineering Educators Association (ITEEA), National Assessment Governing Board, and the National Academy of Engineering (NAE), along with other organizations, have called for a larger involvement in K-12 education for the development of technological literacy in students (ITEA, 1996; National Assessment Governing Board, 2013; Pearson & Young, 2002).

Technological literacy is defined as "the diverse collection of processes and knowledge that people use to extend human abilities and to satisfy human needs and wants" (ITEA, 2000, p. 2). A broad range of academic subjects encompass technological literacy; therefore, development of technological literacy for K-12 students necessitates that all K-12 teachers develop a level of technological competency. According to the NAE and the National Research Council, "the integration of technology content into other subject areas, such as science, mathematics, social studies, English, and art could greatly boost technological literacy" (Pearson &Young, 2002, p. 55). The purpose of this study was to investigate the development of technological literacy in accredited pre-service K-12 teacher education programs in the United States. To guide this study, the following research questions were developed:

1. Are technological literacy courses a part of general education requirements for K-12 education majors at 4-year, accredited institutions?
2. Are technological literacy courses used to fulfill program requirements for K-12 education majors at 4-year, accredited institutions?
3. Do the required technological literacy courses focus on the development of broad technological literacy awareness or is the focus on learning how to use instructional methods similar to those used in technology education activities?
4. What, if any, are the differences in K-12 education majors in requirements for technological literacy courses?

CONTEXT OF THE STUDY

For this study, a distinction was made between *technological literacy* as defined by the ITEEA and technology literacy as defined by the International Society for Technology in Education (ISTE). Technology literacy is concerned with student literacy in computer and information technologies as well as teacher abilities to use computer and information technologies for instruction (ISTE, 1998). Technological literacy is concerned with "how people modify the natural world to suit their own purposes" (ITEA, 2002, p. 2). In reference to Research Question 3, technological literacy includes this definition as well as the relationship among technology, the sciences, and society.

Instructional methods that utilize technology education activities generally involve the design and development of a product, physical or virtual, as a means to improve learning of the subject content (Foster, 1995). These activities promote problem-solving skills essential in a complex society (Schwaller, 1995). Activities include the design process, but may or may not address additional technological literacy content.

The need for a technologically literate populace has been broadly recognized by the relationship between other academic fields and technology education. The National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) provided funding for the Technology for All Americans Project (TfAAP) (ITEA, 1996). Many other organizations supporting technological literacy include the National Research Council (NRC), the National Academy of Engineering (NAE), the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS) Project 2061, and the National Council of Teachers of Mathematics (NCTM) (Dugger, 2005). Additionally, the disciplines of science, mathematics, and social studies have standards that address technological literacy (Achieve, 2014; Foster, 2005).

The NAE and NRC publication, *Tech Tally* (Garmire & Pearson, 2006), includes recommendations in the assessment of technological literacy relevant to this study. Primarily, the focus and recommendations suggest a strong need for teachers to develop technological literacy in K-12 pre-service education programs and to include technological literacy as part of the assessment of K-12 teachers and K-12 teacher education programs. An important step in meeting these recommendations is to develop an understanding of the current status of technological literacy, both in the extent to which coursework is required in K-12 teacher education as well as what aspects of technological literacy are covered in those courses.

METHODOLOGY AND RESEARCH DESIGN

The research design of the study was content analysis. Content analysis is "a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, or biases" (Leedy & Omrod, 2005, p. 142). For this study, a documents review of current undergraduate course catalogs was performed to address the research problem and the content analyzed in order to answer the research questions.

Population and Sample

The K-12 education programs reviewed in the study were randomly selected from the combined lists of education programs accredited through the National Council for Accreditation of Teacher Education (NCATE) and Teacher Education Accreditation Council (TEAC). A single list of 697 accredited education programs within the United States was created by entering the data, available online, into a spreadsheet. The sample size of 248 education programs was determined using a table based on the formula by Krejcie and Morgan (1970) (as cited in Patten, 2007) for a finite population at a 95% confidence level. The random sample was created using the random number generator and sort functions in the spreadsheet software. The sample size and random sample procedure allows for the sample to be proportionally representative of the NCATE and TEAC accredited education institutions in terms of geographic location in the United States, as well as the distribution among liberal arts colleges, regional institutions, and research universities. The education majors to be reviewed represent the academic areas that K-12 students are required to study.

Data Collection Methods

This study used a qualitative analysis of electronic sources of course titles and course descriptions. In a documents review, the researcher makes the judgment on how to code the appropriate data in the document (Creswell, 2007). The data were collected for the study by reviewing the appropriate catalogs for each institution of the 248 education programs in the sample. General education options and requirements as well as education program options and requirements were reviewed to identify courses that may have technological literacy or engineering content. Potential courses were identified and course descriptions were reviewed to determine if they contained technology or engineering content. Additionally, a search was done of all courses offered at the institution using technology, technological, engineering and design. When a course was identified as having technological literacy or engineering content, it was checked against the courses listed in general education and education program options and requirements.

A spreadsheet was used to record data from each institution with categories for mathematics, science, English, social studies, and elementary education programs. Subcategories for elementary education majors included English, social studies, mathematics, and science content specializations. Categories for secondary subjects included a subcategory for middle school majors. Subcategories for secondary social studies included history, geography, economics, political science (including civics), and sociology. Subcategories for science included biology, chemistry, physics, and earth science. There were no content subcategories for mathematics or English.

In order to answer Research Question 1, the general education requirements at each university or college where the teacher education program resided were reviewed. Courses that were identified as developing technological literacy that were general education requirements were identified in one column and those that were an option in a separate column. When the general education courses were not intended for science majors they were coded with an E. Data for Research Question 2 were collected from the teacher education requirements in the undergraduate catalog for each of the education majors evaluated in this study. Where distinctions existed between middle school and high school majors, both sets of requirements were reviewed and recorded separately. Likewise, when differences in science education majors' course requirements existed, they were also recorded separately. Codes for courses are explained in Table 1, which follows. Courses that were identified as developing technological literacy that were teacher education requirements were coded R and those that were an option in teacher education requirements recorded as O. In order to address Research Question 3, the content focus of the required courses, TL or IM was added to the initial code. Courses that focused on instructional methods and technology education activities were coded IM, and courses that focused on technological literacy as content were recorded TL. Courses that addressed both were coded with TL-IM. Therefore, a course that was an education requirement for elementary teacher education that focused on technology education methods as well as content was coded R-TL-IM.

Course content was considered to focus on the development of technological literacy (TL) when the course title or course description indicated that the course curriculum promoted technological literacy as defined in *Technically Speaking* (2002) and *Tech Tally* (2006). *Tech Tally* provided a matrix of the cognitive dimensions of technological literacy and the content areas for technological literacy that were used as a rubric for determining whether a course promoted technological literacy (see Figure 1).

Course content was considered to be technology education instructional methods (IM) when

Table 1: *Codes and Descriptions for Teacher Education Programs*

Codes	Description
R	Required course
O	Optional course used to fulfill requirement
TL	Technological Literacy awareness
IM	Instructional Method using technology education activities

technological literacy courses included instructional methods or activities in the description or title of the course. For example, the course description that follows was an option for an elementary education track at the institution. It clearly describes technological literacy with terms such as systems, products, and technological design. The activities model an instructional method relevant to education majors by having students complete design projects using methods that would be similar and appropriate for the elementary classroom. There were not required courses that met the criteria at this institution, therefore this course is coded O-TL-IM for Optional, Technological Literacy, and Instructional Methods.

> This is a foundational course that looks at the elements and principles of design as related to practical products, systems, and environments. It introduces students to the creative process practiced by artists, designers, and engineers, valuable to them as both future producers and consumers. Content includes thinking, drawing, and modeling skills commonly used by designers; development of a design vocabulary; the nature and evolution of technological design; the impacts of design on the individual, society, and the environment; patents and intellectual property; human factors; team design; and appropriate technology, risk analysis, and futuring techniques. Design problems are presented within real-world contexts, using field trips and outside speakers. Students complete a major design project, document their work through a design portfolio, and present their solutions before the class. Weekly critiques of class projects build fluency, confidence, and creativity. (College of New Jersey, 2008, p. 3).

		COGNITIVE DIMENSIONS		
		KNOWLEDGE	CAPABILITIES	CRITICAL THINKING AND DECISION MAKING
CONTENT AREAS	TECHNOLOGY AND SOCIETY			
	DESIGN			
	PRODUCTS AND SYSTEMS			
	CHARACTERISTICS, CORE CONCEPTS, AND CONNECTIONS			

Figure 1. Assessment matrix for technological literacy (Garmire & Pearson, 2006, p. 53).

Courses that were not included for this study are those that focused on information-technology literacy, computer literacy, or instructional technology as defined by the ISTE (1998) standards. Required courses that focus on these areas were not included in this study because several recent studies have been done in these areas (Baylor & Ritchie, 2002; Hinchlifee, 2003; Kelly & Haber, 2006; Garmire & Pearson, 2006; Sanny & Teale, 2008; Topper, 2004).

FINDINGS AND ANALYSIS

A general conclusion of this study is that there is very little exposure to technological literacy courses for prospective K-12 teachers. The review of literature suggested that this might be due in part to the confusion between instructional technology literacy and technological literacy (Dugger, 2007; Pearson & Young, 2002; Zuga, 2007). All teacher education programs require the acquisition of skills in computer use and instructional technology. This is in large part due to the inclusion of the International Society for Technology in Education (ISTE) National Educational Technology Standards in NCATE accreditation standards for all academic areas (Hinchliffe, 2003; Hofer, 2003). The following are the findings and analysis for each of the four research questions.

Research Question 1: Technological literacy as a part of general education for K-12 education majors

Data analysis identified technological literacy courses as being either a requirement of the institution or an option to fulfill a requirement of the institution. The review of the 248 course catalogs determined that 80 institutions included technological literacy courses as part of their general education requirements. Typical course titles included Science, Technology, and Society, Technology and Society, and Technology and Civilization. At a few of the institutions, these courses were part of a technology track or sequence that would include computer technology courses as well as industrial technology and design courses. Seventy-six of these institutions allowed a technological literacy course to fill a general education requirement, and four institutions required a technological literacy course as part of the general education requirements. Of the 76 institutions that offered a technological literacy course as an option for general education requirements, 42 excluded that course as an option for secondary science majors. Eight institutions identified a technological literacy course that was an option for general education as a requirement for the teacher education program (see Figure 2). The

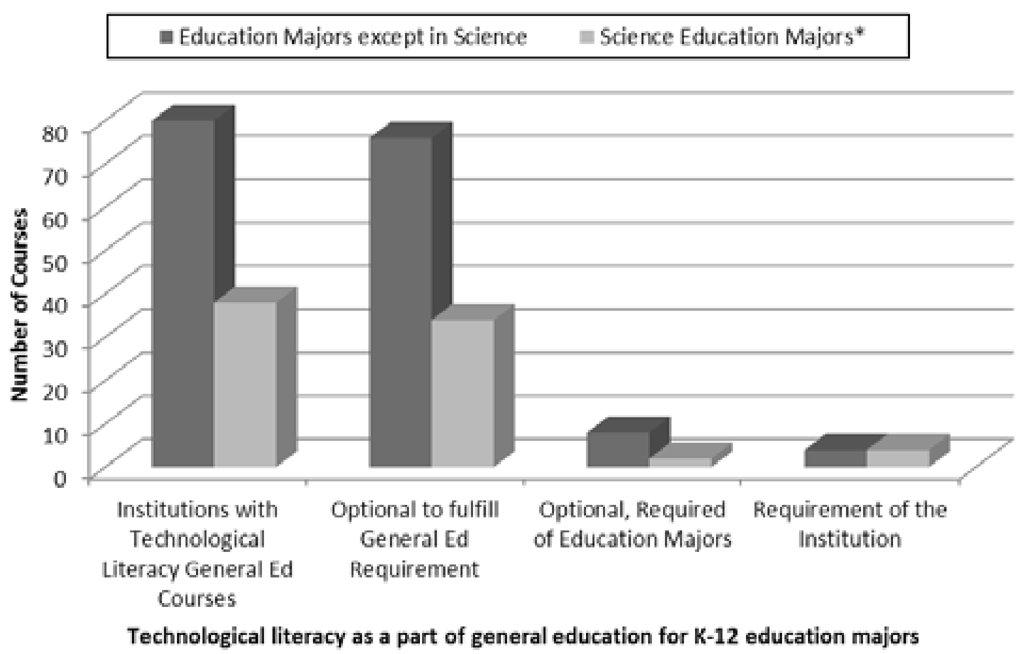

Figure 2. Technological literacy general education courses (* Including elementary science specialization).

narrow understanding of technological literacy as computer literacy may lead some to believe the technological literacy is being addressed in the general education curriculum. A study by Rose (2007) found that administrators in higher education generally believe that science, technology, engineering, and mathematics (STEM) initiatives are addressing technological literacy through computer and digital communication coursework.

Research Question 2: Technological literacy courses used as program requirements for K-12 education majors

For this question, technological literacy courses were identified as either an option or a requirement for the education majors at the institution. Forty-six institutions included technological literacy courses to fulfill program requirements for K-12 education majors. Twenty-seven institutions included technological literacy courses in elementary education; 19 required courses, and eight were optional. For secondary education majors, 29 institutions used technological literacy courses to fulfill program requirements. In addition to the course titles found for general education, some of the course titles required for education majors included Critical Literacies in Childhood Education, Teaching Mathematics, Science and Technology, and Science and Technology. Table 2 shows whether the technological literacy courses were used as a requirement or an option for each of the education majors included in the study. The total number of courses listed in Table 2 does not equal the number of institutions because an institution may have had more than one major with a technological literacy course requirement or option.

Table 2: *Technological Literacy Courses in Teacher Education Institutions, N* = 248

	Required		Option to Fulfill Requirements		Totals	
	#	%	#	%	#	%
Institutions with courses in both elementary and secondary majors	6	2.42%	2	0.81%	8	3.23%
All majors	2	0.81%	1*	0.40%	3	1.21%
Specific majors	4	1.61%	1*	0.40%	5	2.02%
Just elementary majors	12	4.84%	6	2.42%	18	7.26%
Generalist	10	4.03%	6	2.42%	16	7.26%
Specialists	2	0.81%	0	0.00%	2	0.81%
Just secondary majors	14	5.65%	6	2.42%	20	8.06%
All majors	4	1.61%	1	0.40%	5	2.02%
Specific majors	10	4.03%	5*	2.02%	15	6.05%
Totals	32	12.90%	14	5.65%	46	18.55%

* Institutions that had a major with a requirement and a major with an option were included in the option column.

Research Question 3: Technological literacy awareness or instructional methods

The analysis for this question differentiates between technological literacy courses that focus on the nature of technology and/or the relationship of technology and the subject content referred to here as technological literacy awareness. Technological literacy courses that focused on the use of technology education activities as an instructional strategy are referred to as instructional methods. Technological literacy awareness courses were more likely to be found as part of the requirements for secondary education majors, while the distribution between technological literacy awareness and instructional methods was evenly represented in elementary education. Of the 46 institutions identified as having technological literacy courses as part of the requirements for the K-12 education majors, 34 required broad technological literacy awareness courses such as Science, Technology, and Society. Sixteen institutions included broad technological literacy awareness courses as an option. Instructional methods courses, such as Methods for Teaching Math, Science, and Technology, or course descriptions for methods courses that included "the use of robots," "creating maps," and "building models" were required by 19 institutions and were options at three institutions. The total of these is greater than 46 because there were 11 institutions that required courses that address both technological literacy awareness and instructional methods. Most often, these were a single course for elementary education majors such as Critical Literacies in Childhood Education or Elementary Education taught by a technology education department.

Table 3: *Types of Technological Literacy Courses*

	Technological Literacy Awareness		Instructional Methods		Both	
	#	%	#	%	#	%
Required	**23**	**9.27%**	**8**	**3.23%**	**11**	**4.44%**
Elementary Programs	6	2.42%	4	1.61%	8	3.23%
All majors	4	1.61%	4	1.61%	7	2.82%
Specific majors	2	0.81%	0	0.00%	1	0.40%
Secondary Programs	17	6.85%	4	1.61%	3	1.21%
All Majors	3	1.21%	1	0.40%	0	0.00%
Specific Majors	14	5.65%	3	1.21%	3	1.21%
Optional	**14**	**5.65%**	**1**	**0.40%**	**2**	**0.81%**
Elementary Programs	7	2.82%	1	0.40%	2	0.81%
All Majors	7	2.82%	1	0.40%	2	0.81%
Specific Majors	0	0.00%	0	0.00%	0	0.00%
Secondary Programs	9	3.63%	0	0.00%	0	0.00%
All majors	1	0.40%	0	0.00%	0	0.00%
Specific majors	8	3.23%	0	0.00%	0	0.00%
Total Institutions	30	12.10%	6	2.42%	10	4.03%

The findings for elementary education suggest there is a growing understanding of the value of technology education activities for integrating other subjects, as well as the need to develop technological literacy in elementary education. Linnell (2000) identified five programs in the United States that required elementary education majors to take technological literacy courses and 10 institutions that provided these courses as on option. This study, using a sample that is approximately 1/3 of the population, found 18 institutions that required these types of courses for elementary education majors and 10 that provided them as options. Table 3 shows the number of programs that had either required or optional courses for each of the three variables (Technological Literacy Awareness, Instructional Methods, or both).

Research Question 4: Technological literacy course differences in K-12 education majors.

The focus of this question was to determine if there were differences between the education majors of elementary education, English, social studies, mathematics, and science for required or optional technological literacy courses. Technological literacy course requirements were found primarily in elementary education, with secondary science majors having the most courses requirements for secondary education majors.

Table 4: *Comparison of Technological Literacy Courses by Education Major*

	Required		Option		Totals	
	#	%	#	%	#	%
Elementary Education	**19**	**7.66%**	**8**	**3.23%**	**27**	**10.89%**
Generalist	16	6.45%	8	3.23%	24	9.68%
English		0.00%		0.00%	0	0.00%
Social Studies		0.00%		0.00%	0	0.00%
Mathematics		0.00%		0.00%	0	0.00%
Science	3	1.21%		0.00%	3	1.21%
Secondary Majors	**9**	**3.63%**	**5**	**2.02%**	**14**	**5.65%**
All Secondary Subjects*	4	1.61%	1	0.40%	5	2.02%
English		0.00%		0.00%	0	0.00%
Social Studies	3	1.21%	4	1.61%	7	2.82%
Mathematics	2	0.81%		0.00%	2	0.81%
Science Majors	**15**	**6.05%**	**6**	**2.42%**	**21**	**8.47%**
All Sciences Majors	13	5.24%	4	1.61%	17	6.85%
Biology		0.00%		0.00%	0	0.00%
Chemistry		0.00%		0.00%	0	0.00%
Physics	2	0.81%	1	0.40%	3	1.21%
Earth Science		0.00%	1	0.40%	1	0.40%
Total	**43**	**17.34%**	**19**	**7.66%**	**54**	**21.77%**

Note: The findings for middle school and high school are identical, therefore are reported under “Secondary”. There were no differences between social studies majors, therefore social studies are listed as one category. *Includes science majors.

Elementary education had the largest number of programs with required or optional technological literacy course requirements; this included 19 required courses and eight optional courses.

The analysis of the data obtained from the documents review showed differences between the secondary education majors that reflect the literature and standards for these academic areas. Secondary science had 21 programs that include technological literacy courses as part of the requirements with 15 required courses and six optional courses. The rest of the secondary education majors had 14 programs that included technological literacy courses as part of the requirements. This includes the four institutions that required technological literacy courses in all other secondary education programs (including science) and the one institution that provided a technological literacy course as an option in their requirements. Secondary English, except when required by all secondary education majors, did not include programs with requirements for technological literacy courses. There were no differences for the course titles that addressed broad technological literacy in the secondary education majors with titles such as Science, Technology, and Society, and Technology and Society common throughout. The instructional methods course titles included Teaching Math, Science, and Technology, or a description in the methods course that addressed technology education activities. See Table 4 for the complete analysis of the number of programs with required or optional technological literacy course requirements.

The differences between the secondary education majors suggests that the relationship between technology and science is better understood at teacher preparation institutions than the relationship between technology and social studies, and that the relationship between technology and mathematics or English is very poorly understood. These findings are consistent with the literature (AAAS, 1993/2008; Foster, 2005; IRA & NCTE, 1996; NAS & NRC, 1996; NCSS, 2008; NCTM 2000; Newberry & Hallenbeck, 2002; NSTA, 2003).

The standards for science teacher education clearly identify technological literacy as important and include the study of technology and the relationship with science (NSTA, 2003). This is also reflected in *Benchmarks for Science Literacy* chapter on "The Nature of Technology" (AAAS, 1993, pp. 49-52) as well as in *Next Generation Science Standards* (Achieve, 2014). There were 17 institutions that identified technological literacy courses such as Science, Technology, and Society as an option or a requirement for all science education majors.

The standards in social studies also discuss the importance of understanding the relationship between technology and society (NCSS, 1994; Foster, 2005). "Students will develop an understanding of the cultural, social, economic, and clinical effects of technology" and "Students will develop an understanding of the role of society in the development and use of technology," are two examples from the curriculum standards (Foster, 2005, p. 55). Seven institutions included technological literacy courses as a part of the requirements.

The NCATE/NCTM standards for mathematics teachers describe the role of technology as a tool for teaching and understanding mathematics as opposed to the role of mathematics and technological literacy. Standard 6: Knowledge of Technology states, "Use knowledge of mathematics to select and use appropriate technological tools, such as but not limited to, spreadsheets, dynamic graphing tools, computer algebra systems, dynamic statistical packages, graphing calculators, data-collection devices, and presentation software" (NCTM, 2003, p. 2). The findings from the review reflect this—only two institutions require technological literacy coursework.

The National Council of Teachers of English standards lists technology as a tool for research and writing. The standard, "Develop proficiency with the tools of technology" (NCTE, 2008, p. 1) does not distinguish between the broader technology literacy and the ISTE definition, but the supporting literature focuses primarily on the use of computers and the Internet (IRA & NCTE, 1996). There were no institutions, except for the four that required it for all secondary education majors requiring technological literacy coursework for secondary English majors. The professional standards in relation to technological literacy for all these academic areas were reflected in the findings of this study.

RECOMMENDATIONS FOR FURTHER RESEARCH

The inclusion of technological literacy in the Next Generation Science Standards (Achieve, 2014) and National Science Teachers Association's Standards (NSTA, 2003) is reflected in many state standards. This study suggests that there is a discrepancy between the state standards and science teacher education curriculum based on course titles and course descriptions reviewed in this study. State-level studies that identify discrepancies between the state standards and the science teacher education curriculum are needed. These studies could also explore in greater depth the extent of which technological literacy is included in the teacher education curricula through a documents review of course material and data collected from science teacher educators.

Studies by Foster (1997, 2005), Park (2004), Holland (2004), and others have identified the value of elementary school technology education. These qualitative studies show how technology education activities promote learning in an integrated curriculum that is consistent with constructivist learning theory. The value of elementary school technology education has a growing acceptance that is reflected in the number of technological literacy course requirements for elementary teachers. Similar qualitative studies are needed at the middle school and high school levels to show how using technology education instructional methods improve learning in an integrated curriculum.

Studies by Dyer, Reed, and Berry (2006), Culbertson, Daugherty, and Merril (2004), and Satchwell and Loepp (2002) have shown a relationship between student academic achievement and participation in technology education courses. Further research is needed to better understand this relationship. These studies need to address more than the value of technology education for the development of technological literacy; they also should consider the relationship of the development of technological literacy and academic performance in other subject areas.

Finally, this study infers technological literacy of teachers by assessing the extent to which technological literacy courses are included in teacher preparation. Further understanding of the technological literacy of teachers should be addressed through the direct assessment of K-12 teachers through an inventory or survey instrument.

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Technology and Engineering Education Doctoral Students' Perceptions of Their Profession

By Gene Martin, John Ritz, and Michael Kosloski

ABSTRACT

The growth and vitality of both technology and engineering education professions rely on the quality of contributions of its new and emerging leaders. Many of these leaders are currently enrolled students in doctoral programs. These students will be challenged to assume leadership roles in which they are not currently engaged (Ehrenberg, Jakubson, Groen, So, & Price, 2007). Some students may choose to focus their careers in developing new curricula; some will become active in grant writing and grant procurement; some will choose to serve as officers in their professional organizations; and others will contribute to the body of literature in their discipline. Wherever these future leaders decide to focus their efforts, they will likely have an impact on their profession. This study reports on currently enrolled doctoral students' perceptions related to the focus of content taught in formalized K-12 technology and engineering education programs, methods used to prepare future technology and engineering teachers, characteristics of their planned professional involvement, and future forecasting for their school subject. This is the second study by the authors focusing on doctoral students' perceptions.

Key words: Doctoral Students, Perceptions, Professions, Technology and Engineering Education

INTRODUCTION

University faculty work to pass on knowledge of their disciplines and some add to this knowledge through research and development activities. This amalgamation of knowledge is a result of synthesizing one's own ideas, others' ideas, and concepts generated through practice and research. Universities that offer doctoral degrees educate students in best research practices, as well as the knowledge of their disciplines. These same university professors also mentor doctoral students as they guide them through their classes and research projects. Some faculty have expectations that students will present at conferences, write professional papers, and become active members within the professions that operate to support their disciplines (Campbell, Fuller, & Patrick, 2005; Wright, 1999).

In the area of technology and engineering education, there are fewer programs for the preparation of teachers and university faculty (Moye, 2009; Ritz & Martin, 2013). New doctoral students have many tasks ahead of them as they graduate and move into professorships. One area of their work will be to recruit and teach students to become future teachers. Depending upon their employment (e.g., research universities), some will be required to design and undertake an active research agenda. In this task, they will develop research proposals for funding and publish manuscripts on the data they collect. Depending on whether they are employed with a teaching or a research university, some will provide service to school systems, their K-12 state departments of education, and state and national professional associations.

The content for technology education, now called technology and engineering education, emerged from ideas considered in the 1940s that translated to the knowledge that needed to be taught to students, so they might achieve technological literacy (DeVore, 1968; International Technology Education Association [ITEA], 2000; Warner, 1947). With ideas and research produced through the National Center for Engineering and Technology Education (Householder & Hailey, 2012), and the research and development efforts of others, engineering content and processes have moved into the technology and engineering curriculum. In addition, STEM educational reform has added additional attention to science and mathematics within technology and engineering curriculum and instruction (Banks & Barlex, 2014).

With the reformulation of the content for K-12 technology and engineering education, a change has occurred in the focus of activities taught in this school subject. Projects made from templates have been replaced with open-ended design problems where engineering design is the focal point of instruction. Along with the development of new content and instructional practices, changes are emerging in how future teachers will be prepared. Digital technologies now allow courses to be delivered online using various instructional delivery methods.

Professional associations that support the teaching of K-12 programs are also changing. How are associations meeting the needs of professionals teaching technology and engineering education? Will associations also change as the content, methods, and the delivery of teacher education programs change within our school subject? How will new Ph.D.s provide leadership to these organizations as they professionally mature in the 21st century? This research seeks answers to questions of those educators who should emerge as the new leaders of the professions for technology and engineering education. The researchers wanted to further explore the perceptions of current doctoral students in technology and engineering education to determine their views on the content and methods that will be used to deliver K-12 education, strategies to be used to prepare future teachers, if and where they plan to publish, and if they plan to take on an active role in service to their professions.

RESEARCH PROBLEM

This study seeks to identify and provide a better understanding of the perspectives of graduate students currently seeking the doctoral degree on the future of the K-12 school subject of technology and engineering education and the professions that aid in guiding its practice. It was guided by the following research questions:

- RQ_1: What are doctoral students' opinions concerning the focus of content to be learned in K-12 technology and engineering education?
- RQ_2: How do these scholars believe technology and engineering teachers will be prepared in the near future?
- RQ_3: What is the commitment level of these scholars to their technology and engineering teaching professions?
- RQ_4: What does this population expect to happen in the future to the technology and engineering teaching professions?

LITERATURE REVIEW

Literature related to doctoral education, professionalism and professional associations, and the future of professional education associations will be reviewed to provide the reader with a context for understanding the purpose of this study.

Doctoral Education

Debate exists regarding a singular specific purpose of doctoral education, although most descriptions share overlapping characteristics. Though a broad common ground is that doctoral education is intended for the formation of scholars (Walker, Golde, Jones, Bueschel, & Hutchings, 2008), discussion exists concerning the differences between professional and Ph.D. doctorates, how they will be used once completed, and in what type of setting (Neumann, 2005; Sweitzer, 2009; Walker et al., 2008). Although it may vary from field to field, a traditional viewpoint of a Ph.D. is that it primarily prepares scholars to conduct research in an academic setting (Boyce, 2012; Ehrenberg et al., 2007; Shulman, Golde, Bueschel, & Garabedian, 2006). At the other end of the spectrum, a traditional viewpoint of a professional doctorate is that it prepares practitioners who integrate scholarship in applied decision-making (Campbell, Fuller, & Patrick, 2005). Others posit that research theory and applied, practical scholarship should not be examined separately (Evans, 2007; Walker et al., 2008).

Some of the commonalities in most descriptions of doctoral education are that such programs are intended to develop citizens who are technical experts in their fields, contribute knowledge to their respective fields, and also contribute to their profession (Shore, 1991; Walker et al., 2008). In a five-year study sponsored by the Carnegie Initiative on the Doctorate, Walker et al. (2008) developed three broad-based categories in which all competent doctoral programs should be founded. First, doctoral education should provide scholarly integration, which includes not only basic research, but also integrative research and teaching. Walker et al. (2008) and Golde (2007) determined that because approximately one-half of Ph.D.s find careers in higher education, teaching is also an element that should be an integral part of doctoral education.

The second element consistent among doctoral programs is that they develop a sense of intellectual community, which includes the development of a culture within a program and the profession. In other words, it helps to identify one's professional identity and fosters a continuous exchange of ideas in the development of new knowledge (Gardner, 2010; Walker et al., 2008). The third intended purpose of doctoral education is to develop stewards of their professions. Completers are expected to consider uses and applications of their work in their respective fields and exercise responsible application of their knowledge, skills, and principles (Evans, 2007; Walker et al., 2008).

Professionalism and Professional Associations

Professional associations exist for the purpose of supporting and enhancing individuals and groups within their respective professions. However, although members of such associations are bound by a common profession in broad terms, individual members' professional roles may vary widely, posing a challenge for associations to serve all of their members in the same way (Berger, 2014; Jacob et al., 2013). Professional associations, regardless of individual differences among their members, work to unite individuals toward a common purpose and provide the members with a sense of belonging (Patterson & Pointer, 2007).

In the field of education, Berger (2014) believes that professional associations provide leadership for the field, professional development, advocacy, and resources. Jacob et al. (2013) identified a key role in providing specialized networking and collaborative opportunities, facilitating individual interaction, the exchange of ideas, and intellectual growth within a chosen profession. In a study of nursing professionals, Esmaeili, Dehghan-Nayeri, and Negarandeh (2013) identified the purpose of professional associations to include professional support, legislative advocacy, contending with professional problems, and providing clear explanations of their objectives. Patterson and Pointer (2007) stated that associations unite individuals with a common purpose, promote the profession, advocate on behalf of the profession, and offer numerous miscellaneous benefits to its members. Another key role identified is the cultivation of future leadership, as many professional associations are challenged in maintaining both leadership and membership (Shekleton, Preston, & Good, 2010). Blaess, Hollywood, and Grant (2012) held that effective leadership begets membership and growth. Though there are many varying descriptions for the purposes and benefits of professional organizations, some of the common threads among them are mentoring, leadership development, advocacy, and scholarship.

Professional organizations provide benefits to their constituencies in line with their purpose and mission. For example, an effective professional organization nurtures a culture whereby information is evaluated and shared throughout the organization and the profession (ASAE & the Center for Association Leadership, 2006). They tend to foster a sense of community and provide opportunities for professional collaboration, both formally and informally (Jacob et al., 2013). This type of collaboration allows individuals to better internalize not only the nature of their respective fields, but also allows them to congregate with others who share similar specific interests within that field (Berger, 2014). ASAE & The Center for Association Leadership (2006) identified seven benefits of successful professional associations, categorizing each of those benefits into one of the following categories: a sense of purpose, a commitment to analysis and feedback, and a commitment to action. Schneider (2012) studied the importance of the concept of social capital, which he described as aiding membership into understanding that associations and professions have their own unique culture that is dependent on "reciprocal, enforceable trust that develops over time" (p. 205).

Future of Professional Education Associations

As has been noted, professional associations exist to support the development of those who practice in professions. There are associations for most occupations (e.g., professional organizations and unions), and many people who advocate for individual groups (e.g., disabled persons, retired people, sport teams). Some individuals learn of these organizations from family members, teachers, and professors. *Professions* are defined as a collection of self-selected, self-disciplined individuals (professionals) who share a common identity and characteristics. The common "thread" of a profession as used in this study is a collection of individuals who identify themselves with furthering the mission of the technology education school subject (technology education, technology and engineering education, design and technology, etc.).

Professional organizations exist to support the aspirations of members. Some reasons for establishing professional organizations include (a) tackling professional problems, (b) attempting to increase the power of legislative authorities, and (c) clearly explaining their objectives for enhancing organizational power (Esmaeili, Dehghan-Nayeri, & Negarandeh, (2013). Phillips and Leahy (2012) believed professional associations (a) provide for the professional development for their members, (b) set standards for educational practice, (c) organize and host forums on issues important to the members, and (d) attempt to unify political action campaigns to better position the profession. These reasons closely align with the purposes of organizations that support technology and engineering professions (Epsilon Pi Tau, 2013; ITEEA, 2011).

Professional education organizations also debate the changing content and roles of their school subjects. Ritz and Martin (2013) found that new doctoral students consider professional associations as platforms for publishing (in their journals), as providing opportunity to make presentations at international conferences, and as providing professional development opportunities. However, the group studied by Ritz and Martin projected that only 37.5% of the new Ph.D.s would participate in leadership roles in teacher education professional organizations.

Martin (2007) explained the decline in memberships in professional associations. He noted that 9/11 and the resulting effect of tightened organizational budgets have contributed to membership declines. This is especially true of education organizations. The economic decline that began in 2008 has kept K-12 teachers away from conferences, because school systems do not have the funds to support teachers' absences (paying for substitute teachers). In addition, school systems do not have budgets to support teachers and administrators who want to attend conferences. Ritz and Martin's (2013) study found that new Ph.D.s do not see themselves holding leadership positions in professional organizations. Mellado and Castillo (2012) found low levels of satisfaction when the organization's performance has kept some members from choosing to participate in leadership roles. Could it be that new Ph.D.s see slippage in the contributions that these associations have made to members as a reason why they elect not to lead? Do they feel that too much investment of time and effort would be required to "right the ship"?

Although new Ph.D.s do not seek to lead, they do see professional organizations providing "specialized networking and development opportunities to a specific profession, group of individuals or field of study" (Jacob et al., 2013, p. 141). They perceive networking as contributing to their recognition and making partnerships in developing ideas and furthering research agendas. They consider such opportunities as important to their development to achieve tenure and promotion in higher education. However, if these highly educated technology and engineering teacher education students do not seek leadership positions in professional associations, who might fill these voids? This study seeks to provide a better understanding of current doctoral students and their perceptions of the technology and engineering education professions.

RESEARCH DESIGN

The survey method is a quantitative non-experimental research design selected by the researchers for this study. A potential internal threat to validity in survey research is attitudes of subjects. The researchers addressed this threat using a nomination process to select their sample. Lead professors at selected universities were contacted and asked to nominate currently enrolled Ph.D. students for the study. Thus, a purposeful sample of nominated technology/engineering education students became the population for the study. Though the researchers did not attempt to generalize the results of their study to a larger population, they believe that a potential threat to external validity of population generalizability is addressed because the purposeful sample is or very closely resembles the actual population of Ph.D. students. The value of conducting survey research is widely supported in the literature. McMillan and Schumacher (2010) described survey research as a method that is used to "learn about people's attitudes, beliefs, values, demographics, behavior, opinions, habits, desires, ideas, and other types of information" (p. 235). Clark and Creswell (2010) referred to survey research as a method to "determine individual opinions" and a way to "identify important beliefs and attitudes of individuals at one point in time" (p. 175). McMillan (2012) underscored the popularity of survey research because of its "versatility, efficiency, and generalizability" (p. 196). Creswell (2012) addressed the advantage of using cross-sectional survey designs because they have the "advantage of measuring current attitudes or practices" (p. 377).

PROCEDURES

The researchers administered a structured 12-question survey that also contained 5 additional demographic questions. The survey was administered anonymously using a web form in October 2013 with one additional follow-up letter sent to invitees. In the letter of invitation to participate, the researchers assured the invitees that (a) their individual responses would not be identifiable by a participant's name, (b) their participation was voluntary (e.g., lead professors who nominated them would not know if they accepted the invitation to participate in the study), and (c) there were no direct benefits to them by participating in the study. When the researchers received a confirmation from the invitees who were willing to participate, they were sent a URL to complete the survey. Thirty-four invitees ($N = 34$) responded that they wished to participate in the study, and all 34 invitees completed the survey for a 100% response rate. The total elapsed time from the initial letter of invitation to their completion of the survey was approximately two weeks.

The researchers followed best practices in designing the survey instrument, including making several assumptions about the participants prior to commencing their study. These assumptions included but were not limited to the following:

1. Participants were capable of identifying the focus of content to be learned in K-12 technology and engineering education.
2. Participants were capable of identifying the way technology and engineering teachers will be prepared in the near future.
3. Participants were capable of expressing their commitment level to the technology and engineering teaching profession.
4. Participants were capable of identifying what they believe will occur in the future to the technology and engineering teaching profession.

FINDINGS

The participants comprised a purposeful sample of Ph.D. students (N = 34) who are currently pursuing their degree in technology education/ engineering education. Lead professors at five universities that offer the doctoral degree in technology/engineering education nominated the participants. (Lead professors at two other universities were invited to nominate participants but declined due to a lack of Ph.D. students in their programs.) Lead professors at North Carolina State University, Old Dominion University, The University of Georgia, Utah State University, and Virginia Polytechnic and State University nominated the participants.

Data were collected from 34 participants' responses to a 12-question survey. The participants consisted of 16 females (47.1%) and 18 males (52.9%). For purposes of this study, the researchers used the following categories for collecting data on participants' ages: 20-30 years, 31-40 years, 41-50 years, 51-60 years, and 61+ years. The participants reported their primary area of interest as being post-secondary grades ($n = 15$; 44.1%). When asked to identify their current position, the participants were predominantly classroom teachers ($n = 14$; 41.2%). Two participants chose not to identify their current position. Finally, all participants identified the United States as their home country and all were studying in the United States. A summary of the analyses of the demographic data is provided in Table 1. The following narrative reports on data that relate directly to the four Research Questions addressed in this study. The reported data are also presented following the same categories used in the survey – Part 1 and Part 2. Data collected for Part 1 focused on

Research Question 1 and data collected for Part 2 focused on Research Questions 2, 3, and 4.

Part 1

Part 1 of the survey contained four questions and, as previously noted, Part 1 focused entirely on Research Question 1. The participants were first instructed to respond to the question: "What should be the focus of content taught in formalized kindergarten (primary) through high school (secondary) technology and/or engineering education programs." The participants were instructed to "select all that apply" from a menu containing five possible choices: technological literacy, workforce education, design technology/engineering design, STEM integration, and other. STEM integration was selected most often (n = 27; 81.8%) by the participants, followed by design technology/engineering design (n = 23; 69.7%), and Technological Literacy (n = 21; 63.6%). In addition, workforce education was selected 9 times (27.3%). No participant selected "other" as his or her choice. One participant did not answer this question.

Once the participants identified the "focus of content," the researchers directed them to consider the topic of instructional strategies by posing the following question: "What should be the focus of instructional strategies used in formalized kindergarten through high school technology and/or engineering education programs?" Once again, the participants were instructed to select "all that apply" from a menu containing five choices: project-based activity, design-based/engineering design-based activity,

Table 1: *Population Demographics*

Demographic	Selection	Number	Percent
Gender (n = 34)	Female	16	47.1
	Male	18	52.9
Age (n = 34)	20-30	8	23.5
	31-40	10	29.4
	41-50	8	23.5
	51-60	8	23.5
	61+	0	0.0
Area of Professional Interest (n = 34)	Primary/Elementary	5	14.7
	Middle School	5	14.7
	High School	9	26.5
	Post-Secondary	15	44.1
Current Position (n = 32)	Classroom Teacher	14	41.2
	Supervisor	3	8.8
	Teacher Educator	3	8.8
	Private Sector	2	5.9
	Full-Time Student	10	24.9

Note: N = 34. Two respondents chose not to answer the demographic question related to current position.

contextual learning, conceptual learning, and other. Design-based/engineering design-based activity was selected most often (*n* = 28; 82.4%) by the participants, followed by project-based activity (*n* = 24; 70.6%), contextual learning (n = 23; 67.6%), and conceptual learning (*n* = 20; 58.8%). No participant selected "other" as his or her choice.

"Who should be the primary audience for a formalized instructional program in technology and/or engineering education?" is a question that has been addressed by those in the profession for years, if not decades. This specific question directed participants to identify the primary audience while also being instructed to "select only one" possible audience from the following: (a) elementary aged/primary grade students, (b) middle grades (6-8) aged students, (c) high school students, (d) secondary students (middle grades and high school), (e) post-secondary students, and (f) "all of the above identified populations." The participants clearly believe the primary audience should be "all of the above identified populations" (*n* = 20; 58.8%). The next highest response category was secondary students (*n* = 6; 17.6%).

Technology and engineering educators stay abreast of the results of research conducted by others in their discipline by reading articles in professional journals. The final question in Part 1 focused on determining which professional publications they regularly read. A total of 20 publications were identified by the participants and those most often read were *Technology and Engineering Teacher* (*n* = 22), *Journal of Technology Education* (*n* = 15), *Journal of Engineering Education* (*n* = 6), *Prism* (*n* = 5), *Journal of Technology Studies* (*n* = 4), *Techniques* (*n* = 4), *International Journal of Design and Technology* (*n* = 4), and *Children's Journal of Technology and Engineering Education* (*n* = 4). Their responses reveal several insights into the reading interests of this emerging group of professionals. First, engineering journals (*Journal of Engineering Education* and *Prism*) are being read by Ph.D. students. Second, the *Technology and Engineering Teacher* continues to gain their attention because it was identified most often among the journals they read. Interestingly, this journal is considered a practitioner's journal, not a research journal. Third, the *Journal of Career and Technical Education*, published by the Association for Career and Technical Education (ACTE), once considered a staple in every technology education professional's library, now holds little value to this group of readers. Yet, *Techniques*, also published by ACTE, which purports on its website to bring its readership news about legislation affecting career and technical education and in-depth features on issues and programs, gains the attention of these Ph.D. students. Table 2 summarizes data on doctoral students' perceptions regarding current activities within the technology and engineering education profession.

Part 2 of the survey consisted of eight questions that focused on finding answers to Research Questions 2, 3, and 4. The first three questions in Part 2 addressed Research Question 2. In order to maintain a critical mass of classroom teachers who will teach in the technology and engineering instructional programs, students (future teachers) must be prepared to become classroom teachers. Participants were first instructed to identify the primary characteristic that best describes how technology and engineering students will ultimately become classroom teachers. In addition, they were directed to "select only one" possible characteristic from the following list of characteristics: (a) 4- or 5-year campus-based program, similar to what is most prevalent today in higher education; (b) a discipline degree followed by a teaching diploma (license) taking 4 or 5 years to complete; (c) documenting academic qualifications through professional testing; (d) a combination university-school-based program, and (d) other. The characteristic with the highest reported frequency was a discipline degree followed by a teaching diploma (license) taking 4 to 5 years to complete (*n* = 15; 44.1%) with the characteristic of a combination university-school-based program being the second most frequently selected characteristic (*n* = 13; 38.2%).

The researchers then instructed the participants to identify "where" this education/qualification will be received. The participants were instructed to "select all that apply" from a menu containing six possible choices. Clearly, the participants believe hybrid systems that involve blended methods of instructional delivery, including campus and distance learning will be the delivery of choice (*n* = 30; 93.8%). It also is

Table 2: *Part 1, Current Activity within the Profession*

Item	Selection	Number	Percent
1. Content for K-12 T/E ed. (*n* = 33)	Technological Literacy	21	63.6
	Design Technology/ Engineering Design	23	69.7
	STEM Integration	27	81.8
	Workforce Education	9	27.3
2. Focus of Instructional Strategies (*n* = 34)	Project-based	24	70.6
	Design-based	28	82.4
	Contextual	23	67.6
	Conceptual	20	58.8
3. Primary Teaching Audience (*n* = 34)	Elementary School	1	02.9
	Middle School	5	14.7
	High School	1	02.9
	Secondary School	6	17.6
	Post-Secondary School	1	02.9
	All Levels	20	58.8
4. Journals Regularly Read (*n* = 29)	*Technology and Engineering Teacher*	22	64.7
	Journal of Technology Education	15	44.1
	Journal of Engineering Education	6	17.6
	PRISM	5	14.7
	Journal of Technology Studies	4	11.8
	Techniques	4	11.8
	International Journal of Design and Technology Education	4	11.8
	Children's Journal of Technology and Engineering Education	4	11.8

Note: *N* = 34. These numbers exceed the N value and 100%, since respondents could select more than one choice for these questions.

clear that participants had an interest in two other choices provided in the survey: brick and mortar university classroom/laboratories (*n* = 15; 46.9%); and via distance learning technologies (*n* = 10; 31.3%).

Professional development of educators at all levels continues to be a growing concern among educators, administrators, and professional association members. The researchers sought to determine the participants' perceptions of "who" will be the service providers of professional development activities. The participants were instructed to "select all that apply" from a menu containing six possible choices with the sixth choice being "other." However, no participant selected the other category. Teacher education institutions received the highest frequency of responses (*n* = 26; 78.8%), followed by professional associations (*n* = 23; 69.7%), distance learning providers (*n* = 18; 54.5%), and national/regional/district supervisors (*n* = 17; 51.5%). The remaining choice (commercial vendors) recorded the lowest frequency (*n* = 10; 30.3%).

The researchers explored the participants' "commitment" to their profession through a series of four questions that addressed Research Question 3. First, the lifeblood of professional associations comes about through people who choose to hold membership and participate in an association's plan of work. Participants were instructed to identify the professional technology and engineering education associations that they would be members of in 2025. They were instructed to "select all that apply" from a menu containing eight possible choices. No participant selected the eighth and final choice, which was "other." Even though the possible choices represented a breadth of associations that serve the technology and/or engineering education professions, the International Technology and Engineering Educators Association recorded the highest frequency (*n* = 30; 90.9%) among the participants, followed by STEM associations (*n* = 21; 63.6%), American Society for Engineering Education (*n* = 20; 60.6%), and national- and state-level technology and engineering associations (*n* = 19; 57.6%). The participants gave little attention to the European Society for Engineering Education (*n* = 1; 3.00%) and the Design and Technology Association (*n* = 1; 3.00%) as both associations' primary membership service areas are outside the United States.

Another measure of the participants' commitment to their profession is identified by professional conferences they will be regular attendees in 2025. The participants were instructed to "select all that apply" from a menu containing eight possible choices. No participant selected the eighth and final choice, which was "other." Though the possible choices represented a breadth of professional conferences that serve the technology and engineering education professions, the International Technology and Engineering Educators Association recorded the highest frequency/percent (*n* = 26; 81.3%) among the participants followed by national/regional/state level technology and engineering conferences (*n* = 20; 62.5%), and the American Society for Engineering Education conference (*n* = 16; 50.0%). Few participants envisioned attending conferences sponsored by the Design and Technology Association (*n* = 1; 3.1%), Pupil's Attitudes Toward Technology (*n* = 7; 21.9%), Technology Education Research Conference (*n* = 4; 12.5%), and Pacific Rim Technology Education Conference (*n* = 1; 3.1%). It is understandable why these four international conferences might have a low frequency rate as they are typically hosted in countries other than the United States.

Professional publications provide a scholarly venue for professionals to report the findings of research investigations. When technology and engineering educators publish in refereed publications they are, among other things, extending or adding to the body of knowledge in this discipline. The researchers' goal was to determine if the participants planned to publish in the future (presumably after being graduated with the Ph.D.) and if so, in which journals they would be seeking to publish their manuscripts. The participants were instructed to "select all that apply" from a menu containing eight possible choices. No participant selected the eighth and final choice, which was "other." It is clear that our Ph.D. students plan to publish in what may be thought of as traditional United States-based technology education journals – *Technology and Engineering Teacher* (*n* = 27; 84.4%) and *Journal of Technology Education* (*n* = 27; 84.4%). The *International Journal for Technology and Design Education* was selected by 11 (34.4%) participants. A review of their responses to this question and their previously reported responses to the question related to the publications they read most often reveals that though they read engineering-related journals (e.g., *Journal of Engineering Education* and *Prism*), they do not plan to publish in those journals in the future. (See Table 3 for a listing of the most often identified journals that they plan to read and publish manuscripts in the future.)

Finally, the participants were instructed to project to the year 2025 and identify their planned involvement in their professions. They were directed to either check that they would or would not be contributing professionally to technology and engineering education organizations. In addition, if they planned to be active in professional organizations, they were instructed to explain their planned involvement. Clearly, participants (n = 30; 88.2%) plan to be actively involved in their professional organizations, while four (11.8%) participants indicated they would not be actively involved. It remains unclear why four participants would not be contributing members.

"What do you see happening to the technology and/or engineering education profession by the year 2025?" was the final question posed to the participants to address Research Question 4.

Table 3: *Currently Read and Plan to Publish Manuscripts*

Journal	Currently Read Number	Percent	Plan to Publish Manuscript Number	Percent
Technology and Engineering Teacher	22	64.7	27	84.4
Journal of Technology Education	15	44.1	27	84.4
Journal of Engineering Education	6	17.6	0	00.0
PRISM	5	14.7	7	21.9
Techniques	4	11.8	0	00.0
Journal of Technology Studies	4	11.8	5	15.6
International Journal of Design and Technology Education	4	11.8	11	34.4
Children's Technology and Engineering Journal	4	11.8	0	00.0
Design and Technology Education	0	00.0	6	18.8

Note: N = 34. Respondents could have more than one response to questions posed.

Participants were instructed to "select only one of the following" choices: (a) the profession will look very similar to what it looks like today, (b) the profession as we know it today will be integrated in a STEM organization, (c) the profession will be integrated into the science profession, and (d) technology and engineering education will disappear as a teaching profession. Clearly, the participants believe the profession will be integrated into a STEM organization (n = 30; 88.2%) and only two (5.9%) participants believe the profession will look very similar to what it looks like today. Will the profession disappear by the year 2025? Only one (2.9%) participant believed the profession would no longer exist in 2025.

SUMMARY

What did the researchers learn from undertaking this study? Data show that efforts to bring engineering design and STEM principles into the technology and engineering curriculum are now reshaping the content focus for this school subject. These shifts are evident in courses colleges and universities are now offering, publications shared among professionals, and presentations delivered at professional association meetings. This leads educators to ask if the focus of our curriculum and profession will move closer to the engineering or science disciplines in the near future. If this direction is sought, teacher preparation will also need to be transformed. How might new and existing teachers be prepared? Because conference expenses are critical to all school systems' budgets, will distance learning become the modality to update the knowledge and practices of this profession's teachers? With fewer universities and faculty available to provide professional development enrichments for practicing teachers, distance-learning technologies might provide a practical way of learning.

The professional commitment level of current doctoral students is high. This group is committed to the technology and engineering professions. Many plan to become teacher educators. They plan to publish, to attend and present at professional meetings, and to become leaders in their professional organizations. However, what will the profession they plan to lead look like in the future? Many envision moving technology and engineering education practices into engineering, science, or STEM educational communities, where they see themselves practicing their profession. This might change the focus and nature of the technology and engineering education professions. As this study has shown, future leaders are analyzing the content and delivery of technology and engineering concepts for K-12 populations. Time will provide evidence of how this group might reshape our professions in the near future.

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Augmented Reality Applications in Education

By Misty Antonioli, Corinne Blake, and Kelly Sparks

ABSTRACT

Technology is ever changing and ever growing. One of the newest developing technologies is augmented reality (AR), which can be applied to many different existing technologies, such as: computers, tablets, and smartphones. AR technology can also be utilized through wearable components, for example, glasses. Throughout this literature review on AR the following aspects are discussed at length: research explored, theoretical foundations, applications in education, challenges, reactions, and implications. Several different types of AR devices and applications are discussed at length, and an in-depth analysis is done on several studies that have implemented AR technology in an educational setting. This review focuses on how AR technology can be applied, the issues surrounding the use of this technology, viewpoints of those who have worked with AR applications; it also identifies multiple areas to be explored in future research.

Keywords: augmented reality, science education, self-determination theory, flow theory, situated learning theory, just-in-time learning, constructivism

INTRODUCTION

In today's society, technology has become a crucial part of our lives. It has changed how people think and apply knowledge. One of the newest developing technologies is augmented reality (AR), which can be applied to computers, tablets, and smartphones. AR affords the ability to overlay images, text, video, and audio components onto existing images or space. AR technology has gained a following in the educational market for its ability to bridge gaps and bring a more tangible approach to learning. Student-centered activities are enhanced by the incorporation of virtual and real-world experience. Throughout this literature review on AR the following aspects will be discussed at length: research explored, theoretical foundations, applications in education, challenges, reactions, and implications. AR has the potential to change education to become more efficient in the same way that computers and Internet have.

RESEARCH

Research conducted for this literature review focused on educational applications of AR. The initial search of K-12 applications was far too broad to provide a valuable synthesis. The keywords included educational applications, science or STEM focus, and augmented reality. Journals with a concentration in technology and education that held significance to AR within the classroom setting were sought. References were included that explained the concept of AR as well as studies that implemented AR. Most of the references for this analysis were published within the past five years; however, a few articles included were published as early as 2001. The majority of the research found focused on applications in a middle or secondary level. AR appears to have potential extending into lower elementary grades. Additionally, research at the college level provides insight into windows of opportunity that may extend into the K-12 sector. Researchers often choose students at a middle school level because of the critical time period it is for increase in science interest and building self-confidence (Bressler & Bodzin, 2013).

Several studies seemed to take a mixed methods approach combining both quantitative and qualitative analysis. Researchers noted that providing case studies and opportunities for participant feedback extended the wealth of knowledge available and provided key insights to the quantitative data (Bressler & Bodzin, 2013; Enyedy, Danish, Delacruz, & Kumar, 2012; Iordache & Pribenu, 2009; Morrison et al., 2011; Serio, Ibanez, & Carlos, 2013). Qualitative data was also thoroughly inspected, specifically acknowledging the positive and negative components of AR that both students and teachers experienced (Arvanitis et al., 2009; Billinghurst & Dunser, 2012; Bressler, & Bodzin, 2013; DeLucia, Francese, Passero, & Tortoza, 2012; Iordache & Pribeanu, 2009; Morrison et al., 2011; Serio, Ibanez, & Carlos, 2013).

One of the quantitative research studies completed by Dunleavy, Dede, and Mitchell (2009), used a design-based approach with interviews to put the engagement of high school students under the microscope. The authors use the AR situation *Alien Contact!* with role- playing scenarios. The study was conducted over the 2006-2007 school year and used data from three schools in order to determine if AR technologies aid in the learning process. Jefferson High School, Wesley Middle School, and Einstein Middle School are all located in the northeastern United States. Through the collaboration of MIT and the University of Wisconsin at Madison, a hand-held AR program known as *Alien Contact!* was created. This game was designed to focus on several educational aspects such as math, language arts, and scientific literacy (Dunleavy et al., 2009). Students used this device throughout the study to participate in roles and collaborate as a team. The authors found that there was a high level of engagement.

Engagement was also found while using augmented books through a qualitative research study. Billinghurst and Dunser (2012) surveyed user studies concerning elementary and high school students to determine if AR enhances the learning experience. The authors found that, "AR educational media could be a valuable and engaging addition to classroom education and overcome some of the limitations of text-based methods, allowing students to absorb the material according to their preferred learning style" (Billinghurst & Dunser, 2012, p. 60).

THEORETICAL FOUNDATIONS

AR educational programs are student-centered and related to student interests. It allows students to explore the world in an interactive way. Constructivism also encourages students to work collaboratively, and AR provides students the opportunity to do this in a traditional school setting as well as in distance education. Dunleavy et al. (2009) believe that the engagement of the student as well as their identity as a learner is formed by participating in collaborative groups and communities. Constructivism has also changed the role of the teacher to become a facilitator, where the responsibility to organize, synthesize, and analyze content information is in the hands of the learner (DeLucia et al., 2012). Wang (2012) warns that because AR follows a constructive learning theory it does not generate consequences for students' actions as needed, compared to a behavioral learning environment; however, AR can be used to bridge the gap between practical and theoretical learning practices along with real and virtual components being blended together to create a unique learning experience.

AR also relates to the just-in-time learning theory. This theory suggests that students learn information that they need to know now. Collins and Halverston (2009) stressed that teachers should "reconceptualize" how they view learning and "rethink" what they should teach. AR allows them to do both of these things by letting educators use a new and engaging technology to view aspects of the real world in a different way.

Dunleavy et al. (2009) discussed the possible connection between the situated learning theory and AR. According to situated learning theory, learning occurs naturally during activities. Some AR situations, like *Alien Contact!*, allow students to use real-life experiences to facilitate learning. Some learning will occur naturally, as they go through their problem-solving environment. Students will use social interaction and collaboration to learn from one another.

Rigby and Przybylski (2009) identified that AR can be linked to the self-determination theory (SDT). SDT defines learning that occurs through motivation. People have the natural tendency to do what is healthy, interesting, important, and effective. The virtual learner hero situation created in the virtual worlds focused on in this study determined that students are engaged because they are in charge of their own learning. The same concepts can be applied to an educational setting.

Flow theory describes how people who are engaged in meaningful activities are more likely to stay focused. Bressler and Bodzin (2013) investigated a science gaming experience in relation to flow experience. Their study had a mean flow experience score of 82.4%, which indicates that the average student experienced flow throughout the science mystery game that they played on an iPhone. This particular type of AR, as well as various others, connects their real-world surroundings to learning in a new and engaging way.

APPLYING AR IN EDUCATION

AR allows flexibility in use that is attractive to education. AR technology can be utilized through a variety of mediums including desktops, mobile devices, and smartphones. The technology is portable and adaptable to a variety of scenarios. AR can be used to enhance content and instruction within the traditional classroom, supplement instruction in the special education classroom, extend content into the world outside the classroom, and be combined with other technologies to enrich their individual applications.

Traditional classroom uses

In any educational setting, there are often limitations in the various resources available. This is often seen foremost in the traditional classroom. Due to budget restraints or constraints on time, the means to teach students in scenarios that allow them to learn by doing can be a challenge. Desktop AR allows students to combine both real and computer-generated images. Iordache and Pribeanu (2009) used desktop AR that combined a screen, glasses, headphones, and a pointing device that allowed students to conduct a hands-on exploration of a real object, in this case a flat torso, with superimposed virtual images. It would not be feasible to explore the digestive process interactively as these students were able to do along with visualizing the nutrient breakdown and absorption in a classroom setting without the AR technology. Computer images could show the process, but the pointing device allowed students to guide their learning.

Classrooms can shift from the traditional lecture style setting to one that is more lab and student-oriented. A case study conducted with a visual arts class noted that allowing students to freely explore a room that was set up with webcams and desktops encouraged more activity while the students perceived that they were more motivated to learn (Serio et al., 2013). Instead of receiving information via images and lecture, students had access to multimodal representations including text, audio, video, and 3D models.

Quick response (QR) codes can also open up opportunities to have a mixed reality setting within the actual classroom. DeLucia, Francese, Passero, & Tortoza (2012) conducted an evaluation study on collaborative classroom environments in a university setting. Students had access via their mobile devices to information provided directly from the instructor and other students. The QR codes within the classroom allowed for location determination, which was necessary because the information was not available online. Having the virtual environment accessible in a single location encourages consistent and active participation in person instead of just the virtual environment. The learning experience of the traditional classroom was enhanced by the content sharing of both instructor and peers.

Special Education Uses

With the ability to bridge learning and physical barriers, AR has the potential to bring value and high quality educational experiences to students with learning and physical disabilities as well as the special education classroom. Billinghurst and Dunser (2012) found that using augmented storybooks have led to more positive results as students were able to recall stories and have better reading comprehension. Augmented storybooks could especially help students who were less able to comprehend only text-based materials. Physical movement is often a component and consideration for AR tasks. A student who may struggle to engage under normal circumstances can become more actively involved in the kinesthetic nature employed by augmented tasks. Dunleavy et al. (2009) found in their interviews that teachers felt that students who were identified as ADD as well as unmotivated students were 100% engaged in the learning process during an AR simulation.

Because of the variety of tools that can be overlaid in an augmented environment, students with physical disabilities can benefit from the potential learning aides that could be incorporated. Something as simple as overlaying audio for those with visual impairments or text for those with hearing disabilities can be effective tools when considering disability access (Forsyth, 2011). Physical limitations can make handheld AR devices more difficult to work with. Head-mounted displays (HMD) can provide a hands-free device to project the overlay visuals to a student and adjust the images based on the orientation of the student while other devices enable students to interact with the environment via voice recognition, gesture recognition, gaze tracking, and speech recognition (Van Krevelen & Poelman, 2010). Bringing this technology to the classroom has the potential to allow for differentiated instruction and enrichment of the learning experience of students with special needs. Evaluation trials conducted by Arvantis et al. (2009) showed that using wearable AR technology with students who had physical disabilities produced, "interestingly comparable results with able-bodied users," (p. 250) in terms of "wearability" and pedagogy.

Outside the Classroom

Mobile applications can extend the traditional classroom beyond the physical walls. Annetta, Burton, Frazier, Cheng, and Chmiel (2012) reported that the percentage of 12 to 17 year olds who have their own mobile device is 75%, compared to 45% in 2004, and regardless of a student's socioeconomic status, the number of students carrying their own mobile devices is growing exponentially every year. Camera phones and smartphones allow users to gather information in a variety of locations. QR codes and GPS coordinates can be used to track and guide movement of the students. Although several researchers chose to take students off campus and conduct investigations in a field trip setting, others chose to remain within the grounds of the school.

In an off campus setting, the AR technology needs to be portable and relatively easy to use. Students traveling to a local pond have the ability to study water quality at specific locations while having access to overlaid media about the pond from the AR device (Kamarainen et al., 2013). This type of experience opens up a world of opportunities to mesh classroom information into the real-world environment. Morrison et al. (2011) used real paper maps and GPS coordinates in a treasure-hunt-style game that allowed for group collaboration. Participants in the game were aware of their surroundings and chose to work together on a task that fostered small group collaboration. An important point to note from this research is that GPS will not work inside of buildings. Therefore, any indoor activity would need to be conducted without a location-based AR technology.

Using QR codes allows individuals a means to avoid relying on location-based technology and focus on the augmented experience. Bressler and Bodzin (2013) chose to use vision-based mobile AR within the confines of the school campus. Students used iPhones that were Wi-Fi enabled to collaborate in small groups to complete a science inquiry game. Not only did the technology enable the students to move freely about the campus, but also the design of the game fostered a social constructivist approach by using a jigsaw method in which students had independent roles that relied upon one another to complete the task. Dunleavy et al. (2009) employed a similar approach to jigsaw collaborative methods for successful completion of an AR simulation.

Combined Learning

The technology employed with AR does not need to be exclusive to the AR experience. Motion sensors that modeled force and motion during Learning Physics through Play (LPP) activities and AR in the form of QR codes enabled students to use, visualize ideas and share them with others for discussion (Enyedy et al., 2012). Combining the technologies helped to enhance the learning experience, which is similar to research done by Kamarinen et al. (2013) who pointed out that the combination can help to enhance the learning experience in a way that neither could do alone.

If an educator is looking to model scientific practice, AR provides the opportunity to support the multifaceted world of science exploration. As a general rule, scientific researchers typically do not use a single tool for evidence to come to a conclusion. Likewise, a literature review that embodies just research from one scientific journal does not begin to tap the wealth of knowledge widely available. Using probeware and sensors to collect data and AR technology to guide and visualize helps to bring a more student-centered dynamic to a learning experience, resulting in gains in student engagement and content understanding (Enyedy et al., 2012; Kamarinen et al., 2013).

Applications Beyond Science

Research shows that the use of AR, regardless of grade level or subject area, allows students to be actively engaged in the learning process. "Building and using AR scenes combines active complex problem solving and teamwork to create engaging educational experiences to teach science, math, or language skills, and studies have found that this activity enhances student motivation, involvement, and engagement" (Billinghurst & Dunser, 2012, p. 60). Though most research shows the use of AR in education through middle school science, there are some implementations in other subject areas and age groups. For example, AR was utilized in a visual arts class as researched by Serio et al. (2013) and during the MapLens research by Morrison et al. (2011) when participants ranging in age from 7 to 50 were observed.

Outside of a traditional school setting, AR has many uses and can be applied to other areas of interest as well. The medical field can utilize this technology to see information about the body systems without having to leave the sight of the patient. In addition, families can see what furniture will look like in their house before purchasing, contractors are able to design different components and see how they will fit together before construction, and tourists can find information out about the area without an in-person tour guide. Van Krevelen and Poelman (2010), determined that AR can be particularly helpful in industrial situations in designing and assembling vehicles as well as military applications for combat training. Companies such as Volkswagen and BMW have already started to use AR technologies in their assembly lines (Van Krevelen & Poelman, 2010). Therefore, AR has many benefits outside of the educational field.

CHALLENGES

Training

Training is an important aspect of AR. "Most educational AR systems are single-use prototypes for specific projects, so it is difficult to generalize evaluation results" (Billinghurst & Dunser, 2012, p. 61). Each AR situation researched was unique and required a different program and requirements of the educator. Due to this uniqueness, training is needed for both educators and students to understand how to utilize each AR program to its fullest potential. During the Dunleavy et al. (2009) *Alien Contact!* AR lesson, teachers expressed a concern for more support. Teachers did not feel confident when setting up or implementing the program. In addition, teachers who are normally lecture focused had a hard time letting go and allowing students to explore the learning environment on their own. A training should be provided for teachers to learn a hands-off approach with their students and show them how this way of teaching will foster an effective learning environment. The fear of not knowing what is on each student's device can be elevated according to the authors through the process of allowing the students more control over their learning. In addition, Kamarainen et al. (2013) also found that teachers felt they would be unprepared to manage the same experience over again if they were by themselves without the researchers present. Training should be provided to the educators from the researchers if continued use of the AR technology is expected to be implemented.

Many AR applications require the use of the environment to set up areas for study. Students walk around and use their AR technology devices in order to receive information. The information must be triggered by either GPS coordinates or other methods when students get near the correct locations. The developer, as well as the educator, must be aware of the environment in order for this to work effectively (Van Krevelen & Poelman, 2010). Therefore, teachers need to either train themselves or attend training sessions on the environment that they can use. For example, if an AR application is specifically designed to be completed in a school where students get close to fire alarms, information appears on their device about fire safety, and the educator or developer must be aware of where all the fire alarms are located.

Resources

Billinghurst and Dunser (2012) understood that there are many aspects of AR that are considered to be obstacles when trying to implement this type of technology in the classroom. Many teachers do not have the skills to program their own AR learning experience and therefore must rely on the ability to create this AR environment through pre-made creation tools, which are rare. This was slightly contradicting to the Annetta et al. (2012) statement that there are many free resources available for teacher use but stress that because teachers are not properly trained they are unable to use these available resources.

AR tools are becoming more user-friendly and require less programming skills making them more attractive to the common educator. Mullen

(2011) focused his work around providing individuals with a resource for basic skills that would enable them to not only understand how AR applications run but also to get started with creating AR content. Kamarainen et al. (2013) pointed out that AR platforms could be employed that allow "an author to create augmented reality games and experiences with no programming experience required" (p. 547). In addition, Billinghurst and Dunser (2012) predicted that by the year 2030, students will be building AR educational content on a regular basis to connect collaboratively with the outside world from within their classroom.

Technical Problems

Dunleavy et al. (2009) showed that the GPS failed 15-30% during the study. A GPS error refers to either the software of the GPS itself or incorrect setup. This was considered the "most significant" malfunction. Other malfunctions identified in this study were the ability for the devices to be effectively used outdoors. The glare from the sun as well as the noisy environment could impair the learning of the students.

Morrison et al. (2011) identified that students who collaborate in teams score higher than students who worked on their own. These multi-user teams need to share information with each other. Therefore, one of the challenges identified in this study is the need for developers to create places for collaboration among team members. Without this additional platform, the successfulness of the AR environment can be compromised.

There are several different kinds of devices that can be used when implementing AR in the classroom. Glasses, hand-held devices, and headwear are ways for the user to see computer-generated images imprinted on their reality. Iordache and Pribeanu (2009) determined that the cameras the students were using should be hands free and that they should be set at table level for the maximum results. Carrying around large devices can make AR inconvenient and frustrating. Arvanitis et al. (2009) had students wear a backpack as part of their AR technology device. The study showed that students felt that it was hard to wear and made them feel embarrassed. If AR technologies hinder the self-esteem of the students, this can also affect how much information the student can retain within each lesson. Van Krevelen and Poelman (2010) also identify that certain AR technologies can be uncomfortable and embarrassing to wear. Gloves, backpacks, and headgear can all cause a student to become uncomfortable and distract them from the purpose of the assignment. In addition, such items could potentially discourage students from trying AR in the first place.

Van Krevelen and Poelman (2010) identified the need for the AR technologies to be designed effectively and with high usability. For instance, the video display must make sure that the images shown do not appear closer or farther away than they really are. This problem can lead to misconceptions if dealing with location-specific tasks. Some devices may require calibration, and this can potentially be very difficult to do. Acquiring devices that are calibration free or auto-calibrated can be beneficial to the user as to avoid malfunction and user frustration.

Bressler and Bodzin (2013) found that players involved in gameplay within the building did not fully utilize the GPS on their mobile device, since the students were familiar with their surroundings. This seemed to reduce the overall cognitive load; however, location-based AR can add a new level of frustration when students are placed in an unfamiliar place, where they must rely on GPS navigation to complete gameplay. Using AR technologies that include both audio and visual components can allow students to use their cognitive abilities to retain information more efficiently based on cognitive load theory.

Student Issues

One issue identified in Dunleavy et al. (2009) determined that some AR situations can be dangerous. In this particular *Alien Contact!* scenario, students must look at their handheld devices to participate. When engaging in activities outdoors the students are unable to work on their devices and watch where they are going simultaneously. Therefore, students were found to be wandering into roadways and needed to be redirected to safety by teachers.

Some of the AR learning experiences require the student to be mobile. Exploring the world is not an uncommon task; however, Annetta et al. (2012) were concerned with gaining approval from school administration for students to travel outside of the classroom. Without this component the teachers and students would be very limited in their use of the AR technologies. The authors found that classroom management is an important part of using AR technologies with students.

Certain health problems can arise from using AR devices if they are not properly designed. Tunnel vision can be a side effect of using poorly designed AR devices, and this should be avoided (Van Krevelen & Poelman, 2010). Developers and educators should be aware of the method and the amount of information being presented. This could prevent the brain from being overloaded. In addition, when the user feels overwhelmed, stress and other frustration can arise, which will distract the student from the objective of learning.

AR learning environments are often designed to have many roles in order for students to work in teams and collaborate with each other. Dunleavy et al. (2009) stated, "As is, if one of the roles is absent, it severely restricts if not disables the game" (p. 19). Student absences are a natural occurrence but affect the learning environment drastically. In addition, students who are working without constraints can rush through or skip information depending on the AR program, teacher assertiveness, and intrinsic motivation. Kamaraien et al. (2013) also found that students might rush through the activity without fully comprehending the information presented in that part. Therefore, though AR leads to a high engagement level students should be monitored to stay on task and on pace as well.

As AR scenarios are developed for the classroom the developers must be aware of their target audience. For example, Enyedy et al. (2012) made a point that the AR technology used in their experiment was made for students to be able to make right and wrong decisions in order to foster play; however, this would not be the ideal situation for older students learning physics. Therefore, the cognitive development of the students should be taken into consideration when developing programs as well as utilizing already existing AR applications.

REACTIONS

Students

Overall, students reacted positively to using AR technology both in and outside of the classroom. AR is a fairly new development within the field of education, and there are areas that students reported that need improvement. Annetta et al. (2012; as cited in Benford and colleagues, 2003) listed four educational uses to AR mobile technology, which are in no particular order: field science, field visits, games, information services, and guides. AR games can be played independently or dependently. Researchers, teachers, and students alike were very pleased to find more collaboration while using the AR technology (Annetta et al., 2012; Billinghurst & Dunser, 2012; Bressler & Bodzin, 2013; DeLucia et al., 2012; Dunleavy et al., 2009; Kamarainen et al., 2013; Morrison et al., 2011). Students reported after completing an AR game called *School Scene Investigators: The Case of the Stolen Score Sheets (SSI)* they had a desire to perform at a higher level, felt a sense of exploration, and 93% of students were more curious to learn about forensics (Bressler & Bodzin, 2013).

Students also reported that learning in an AR environment is more stimulating and appealing than viewing a traditional slide presentation (i.e., Microsoft PowerPoint, SmartNotebook) because they preferred the audio, video, and feeling as if they were part of the 3D model that was transposed into a real physical space (Serio et al., 2013). Finding "hotspots" also known as "triggers," and using the smartphone were both reported as what the students really enjoyed while using AR technology (Kamarainen et al., 2013). Utilizing handheld devices was considered the most motivating and engaging factor when students played the AR simulation game *Alien Contact!* (Dunleavy et al., 2009).

AR is continuously growing and improving every day, and using students' feedback allows AR technology developers to incorporate these helpful tips to improve user experience. Students had issues keeping the AR superimposed images in the right position; they could not select an image as well as they would have liked, and sometimes the image was shaky, which could ultimately lead the program to lose the image altogether (Iordache & Pribeanu, 2009; Serio et al. 2013). DeLucia et al. (2012) noticed that when using AR technology the students had to hold the mobile device in order to complete the activity, which limited the users' maneuverability. To work around these situations, Morrison et al. (2011) found that users would sit down to stabilize their device. Other researchers used head-mounted displays (HMD) for students with muscular dystrophy, cerebral palsy, and arthogerposis to experience AR simulations (Arvanitis et al., 2009). These students used the HMD because they depended on a wheelchair for their mobility. Students felt embarrassed and self-conscious wearing the HMD, and they also found the device uncomfortable. Both Arvanitis et al. (2009) and Iordache and Pribeanu (2009) reported stress on student vision after completing the AR simulation. However, Goodrich (2013) noted that technology developers are already working on a more user-friendly AR technology called Google Glass. This device is set up like a pair of glasses the student could wear with ease and confidence. The superimposed images are displayed to the glasses through a small projector that is viewed only by the individual student. Researchers are working on expanding this technology to include bionic eyes that function without the glasses and would have far reaching potential for students with visual impairments (DNews, 2013).

GPS is a major factor in completing AR simulations. GPS signals are not normally obtained in a building and to adapt, in order for AR simulations to function properly inside a classroom, QR codes have been developed. The mobile device using AR technology can scan a QR code and retrieve the information, where it is then loaded on the device (Bressler & Bodzin, 2013; DeLucia et al., 2012). Dunleavy et al. (2009) found that the biggest limitation for students and teachers while completing a simulation was GPS error.

Educators

Educators may feel alarmed as if AR will “overtake” their classrooms; it seems that once students experience this type of learning, they will not go back to their previous ways of learning. However, Annetta et al. (2012) expresseed that AR can be an activity to engage students in future units and discussions. Billinghurst and Dunser (2012) believe that AR is a new form of face-to-face instruction, as students share the learning experience. Teachers have reported students taking responsibility and ownership of their learning (Kamarainen et al., 2013). Therefore, educators using AR technology are becoming facilitators to their students. Even within the elementary grade levels, teachers plays a very important role in engaging the students, especially when introducing complex technical equipment to their students so they can take part in AR activities (Enyedy et al., 2012).

Teachers are concerned with the programming and coding that is required to integrate AR activities into their classrooms. Software is being developed (i.e., The Art of Illusion) in order for teachers to focus on building educational content and not having to worry about programming skills (Billinghurst & Dunser, 2012). Another concern is how quickly some students are completing the AR activity in comparison to other students. Going through the activity too quickly, as the student cannot wait to see what will come up next on the screen, can hinder their comprehension (Kamarainen et al., 2013; Dunleavy et al., 2009). In contrast, Serio et al. (2013) mentioned that students who finished early or could fix technical problems were willing to help other students. When using AR on a field trip, teachers expressed concern with how they would manage all of the technology, along with technical difficulties that arise throughout the trip—on their own.

Some AR simulation games require a significant amount of complex material the student must process. For example, running the mobile device, using the AR software, following the navigation, completing all the required tasks for the activity, and collaborating with peers about the information, can be quite daunting tasks, even for a student who is advanced at multitasking. Teachers are always looking out for the best interest of their students resulting in worry that AR simulations may cause students to have cognitive overload. Students reported cognitive overload when participating in an outside AR game, and teachers could expect this to be more likely to happen when students are in an unfamiliar area (Dunleavy et al., 2009).

Administration

One of the advantages of AR simulations is it allows students to participate in multiple field trip-like experiences from the comfort of their own building, which can be a huge incentive for districts that are affected by budget constraints (Dunleavy et al., 2009). AR simulations can take place in or outside of the traditional classroom, and administrative support is needed in all cases. For example, administrative approval is needed anytime traveling outside of the school's premises. Innovative teachers can capture administrative support for their students using AR technologies by maintaining strong classroom management skills and, equally important, facilitating good instruction (Annetta et al., 2012).

IMPLICATIONS FOR RESEARCH

The importance of this literature review is that it not only showcases the current trends in AR technology but also its focus on the increased research and potential further application in the educational setting. Several components remain to be explored. When using AR outside of the classroom, teachers and students are able to use this as a tool for physical activity (Dunleavy et al., 2009). Linking learning with exercise and activity in an educational way can improve the perception that technology creates a non-interactive environment (NAEYC & Fred Rogers Center, 2012). Since AR varies in the amount of room required, there is a concern for how much space is needed in order to make implementation successful (Dunleavy et al., 2009; Morrison et al., 2011; Wither, Tsai, & Azuma, 2011). Particular interest within AR is that it has not expanded to fully utilize other learning styles, such as audio and kinesthetic (Billinghurst & Dunser, 2012). Another is that the amount of visual information that can be displayed on the screen can be overwhelming to students. Studies should further explore the effects AR has on cognitive load in the brain and how much information should be displayed before it turns from a beneficial device into a distracting device (Bressler & Bodzin, 2013; Van Krevelen & Poelman, 2010). Many educators are already concerned with how to hold students' attention to keep them engaged throughout the lesson and maintain focus beyond the novelty of the technology (Kamarainen et al., 2013). In one study, Serio et al. (2013) discussed how AR could potentially increase memorization and concentration skills and suggested that further research should be conducted to validate these claims.

Educators must be digitally literate with an understanding of child development theory to select digital tools that are age specific and avoid the potential negative impact on learning (NAEYC & Fred Rogers Center, 2012). Dunleavy et al. (2009) pointed out the challenges of using AR before students have collaborative problem solving skill sets and behaviors that are necessary for learning, the tendency for student competitiveness, and the infancy of effective instructional design. How these challenges factor into placement of AR materials in a single classroom or broad age level warrants extensive focus by future researchers. Although much of the research focuses on student or teacher reactions to AR in the classroom and how it can be used, the technology itself has not allowed for long-term studies on the appropriate guidelines to implementation that will assure student growth and achievement of learning goals. The long-term effect of AR past a single classroom or group of students needs to be evaluated and compared. DeLucia et al. (2012) suggested that the effects of their AR system be evaluated over a longer period of time. Supplementary research could explore what is the most appropriate range of members utilizing AR in groups and when is the best time for AR to be introduced (Dunleavy et al., 2009). To further expand upon possible future research, additional studies would need to seek out if students using AR communicate more effectively and frequently compared to students who are not exposed to AR platforms (Arvanitis et al., 2009; Rigby & Przybylski, 2009). Throughout the multiple studies that were examined, many of them suggested further analysis in what types of AR platforms would be the best fit for educational purposes (Azuma, Baillot, Behringer, Feiner, Julier, & MacIntyre, 2001; Dunleavy et al., 2009; Forsyth, 2011; Iordache & Pribeanu, 2009).

CONCLUSION

AR has already begun to help students learn more efficiently as well as increase their knowledge retention (Billinghurst & Dunser, 2012). However, before AR becomes mainstream in education, like desktops, laptops, tablets, and even cell phones have become, special consideration must be taken into account on the usability, cost, power usage, visual appearance and the like, in order for content AR simulations activities to become part of the regular academic curriculum (Van Krevelen & Poelman, 2010). AR has proved to be an engaging way for students to participate in their learning. This new technology allows the learning to be student-centered and create opportunities for collaboration that fosters a deeper understanding of the content. AR is on the way to becoming an important part of education, and its use will continue to grow.

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