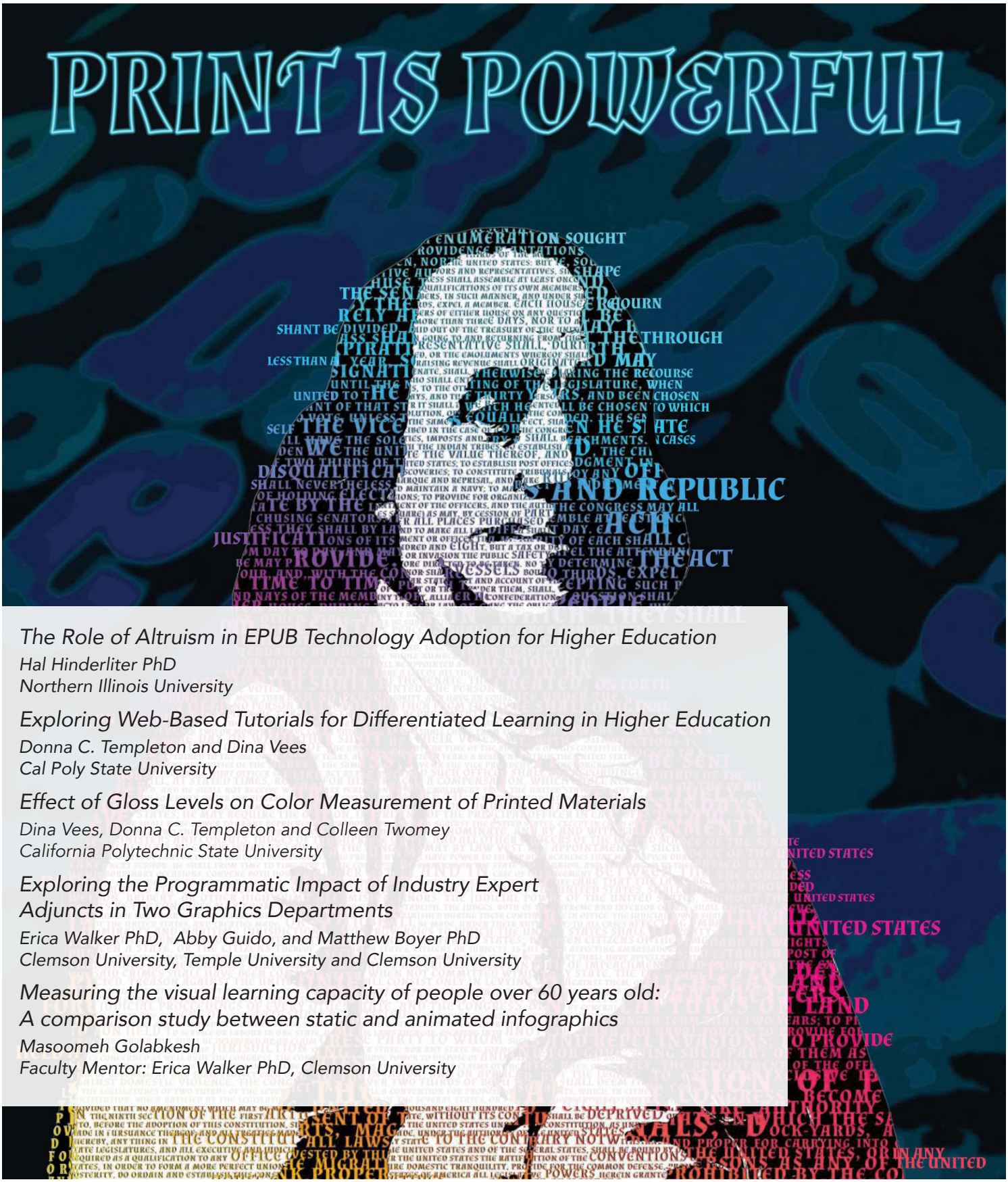
Visual Communications Journal

Fall 2021 Volume 57 Number 2



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VISUAL COMMUNICATIONS JOURNAL

VCJ

VOLUME 57 NUMBER 2 FALL 2021

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Reference Sources

The Visual Communications Journal can be found on EBSCOHost databases.
ISSN: Print: 0507-1658 Web: 2155-2428

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The Role of Altruism in EPUB Technology Adoption for Higher Education

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Abstract

Although overlooked in early work on the topic, altruism has been shown to affect motivation. Recent research has positioned altruism as an important factor in the encouragement of technology adoption. This study examines altruism's role in technology adoption within the context of universal design, which indicates the use of texts that are compatible with assistive technologies. As the need for accessible document formats in our classrooms leads educators to consider transitioning from PDF to the more accessible EPUB format, this research enumerates factors that may motivate abled students to adopt this new technology. Through qualitative analyses of six participants' statements and actions while using EPUBs, four primary motivational factors were identified: compliance, ease of use, convenience, and altruism. While altruism proved to be the least motivational of these four factors, the university students who participated in the current study expressed their willingness to adopt EPUB technology for course readings, with their statements and observed abilities indicating that substantive resistance to adoption would be unlikely.

Keywords: Technology acceptance; Technology adoption; Altruism; EPUB; universal design; UDL; Accessibility

Introduction

Technological innovations have the potential to improve society, but most will require adoption by a substantial user base to yield an impact. One established method for quantifying users' willingness to transition to a new technology is the Technology Acceptance Model (TAM), developed by Davis (1989). Chen et al. (2017) extended Davis' TAM to include additional motivational factors of social interaction, enjoyment, and altruism. Chen et al. found altruism to be a highly significant component of social interaction (p. 8), supporting the assertion that interest in helping others can motivate users to adopt new technologies. In some instances, the role of altruism as a motivational factor grows in importance. Whenever the new technology on offer is intended to enhance accessibility, whether in the physical world, e.g., entrance ramps, or the digital realm, e.g., closed captions for videos, the majority of users are asked to embrace an innovation that may be of little personal benefit.

One such innovation seeks to improve the accessibility of digital documents by encouraging educators, librarians, and publishers to abandon the Portable Document Format (PDF) in favor of the EPUB (not an acronym) format. While PDFs can be made accessible to audiences that use screen readers, refreshable Braille terminals, or other forms of assistive technology, such formatting requires additional steps that most authors do not perform; as a result, educators and librarians often distribute course readings and other texts via PDFs that are not optimized for accessibility. Advocates for learners with visual and cognitive impairments (DAISY Consortium, 2011) have recommended that documents instead be saved in the EPUB format, as this format offers built-in accessibility without the need for additional remediation.

The problem addressed by the current study is that we do not know enough about student preferences for EPUB versus PDF. More specifically, it is unclear if the sighted majority might resist the adoption of EPUB as a replacement for the familiar PDF, despite the clear benefits that such a change would provide for learners with "print disabilities" (Wise, 2016).

Purpose

The current study focuses on a gap in our current knowledge regarding the role of altruism in college students' motivation to adopt the EPUB format for the dissemination and storage of electronic documents. During individual in-person interviews, user reactions and preferences were noted as subjects examined the same publication in two formats: as a PDF and as an EPUB. To shed light on each participant's motivation to use the new EPUB technology, a qualitative examination of responses to open-ended interview questions was conducted.

Research Questions

Observation of participants' interactions with technology and responses to semi-structured interview questions were designed to provide data on the following research questions:

RQ1: What is participants' knowledge of the EPUB format?

RQ2: What challenges are reported or observed when participants access EPUB files?

RQ3: How do participants perceive EPUB's constraints and affordances?

RQ4: Does altruism motivate participants to adopt the EPUB format?

Significance of the Study

Although altruism has been investigated in the past, the connection between altruism and technology adoption is relatively new. The current study adds to our knowledge about this phenomenon, specifically regarding the role that altruism may play in motivating university students to adopt a new format for digital documents. The need for research on EPUB adoption is clear, in that we should avoid the provisioning of alternate accommodations for those who differ from the majority but instead strive for universally acceptable formats "which, to the greatest extent possible, can be used by everyone" (Mace, 1988, p. 3). By observing a small number of abled college undergraduates as they interact with EPUB documents then speaking to them at length about that experience, this qualitative research hopes to add to the discussion of whether "typical" college students can be successfully motivated to adopt this new technology. Specifically, the purpose of the current study was to better understand the potential for user resistance to adopting EPUB as a replacement for PDFs in academic settings with a special interest in the role that altruism might play in overcoming such resistance.

Theoretical Framework

The current study is based on Chen et al.'s (2017) extension of Davis' (1989) Technology Acceptance Model (TAM). Davis theorized that users' motivation to accept new technologies was driven largely by perceived usefulness and perceived ease of use, which

together influenced these users' attitude towards using the new technology; to that end, he developed a widely used instrument for measuring user motivation in technology adoption. Chen et al. (2017) invoked TAM in an investigation of mobile videogaming, expanding TAM to include five additional constructs: altruism, social interaction, use context, perceived enjoyment, and flow. These factors contributed to the development of users' behavior intention, i.e., the likelihood that they will continue to engage in the use of the new technology (Chen et al., 2017, p. 3).

The phenomenon of interest to the current research, EPUB use, manifests the concept of universal design (Mace, 1988) as embodied in the pedagogical theory Universal Design for Learning (UDL) (Rose et al., 2006). While universal design is not directly examined, its assumption that instructors should prefer media and strategies that are accessible to all learners (as opposed to accommodations for specific individuals) is the current study's basis for examining the adoption of EPUB technology.

Definition of Key Terms

Altruism has been defined as human behavior in which people experience concern for the well-being of others and recognize that their actions have consequences for these others (Nagel, 1970, p. 28). Prior research (e.g., Ashton et al., 1998; Krebs, 2006) in the social sciences has emphasized two types of altruism: kin altruism and reciprocal altruism. Within the current study, the fraternal nature of college life is assumed to support a quasi-kinship relationship among students attending the same institution. However, altruism as seen in the current research was best framed by Tooby and Cosmides (1996) as the "Banker's Paradox," in that "assisting one individual may take time, resources, or be dangerous to oneself – it therefore precludes other worthwhile activities" (p. 132). Following this position, this research investigates whether abled individuals will rationalize the resources they must invest to learn a new technology as too costly to justify taking actions that benefit others.

PDF documents have become ubiquitous, but in the early 1990s PDF was only one of multiple formats competing to solve the "transportability" problem. At that time, exchanging documents saved in a particular software's native file format was the status quo. This practice suffered from several disadvantages: the recipient needed to own the same software used by the author, graphics might fail to appear when the document was opened, and the recipient needed to install and activate the same fonts used by the author to avoid unwanted text re-wrap due to the substituted font's differing character width. PDF resolved these issues by encoding fonts and graphics into a single file that could be viewed and printed using Adobe's free Acrobat Reader software. PDF's success in addressing the exigency created by the exchange of native file formats resulted in its rapid – and largely unexamined – adoption within academia.

Soon after, the advent of *screen reader* software allowed the text within digital documents to be read aloud for visually impaired learners via a computer-generated synthetic voice. Interest in providing greater accessibility led Adobe to add an optional layer of structured data to the PDF format, including reading order instructions as well as alternate descriptions for images. However, these capabilities are rarely instantiated because the process of creating a fully accessible PDF is complex, typically only partially completed by authors, and requires the use of Adobe's full Acrobat Pro software. Due to these issues, it can be difficult for instructors and librarians to ascertain whether the individual PDFs they distribute are accessible to users of assistive technologies (AT). As a result, AT users often encounter difficulties accessing the content of PDF documents. As noted by Eikebrokk et al. (2014), "PDF is a format that can cause many barriers, especially for users of screen readers (synthetic speech or Braille)" (para. 7).

In contrast, the EPUB format was designed to provide access by default. EPUBs are a direct descendent of the Digital Audio-based Information System "talking book" (DTBook) developed in 1993 by the Swedish Library of Talking Books and Braille and the software company Labyrinten Data AB. Based on easily parsed collections of XHTML, XML, and CSS files, the simplicity of EPUB stands apart from PDF's mixture of ACSII and binary data (Lukan, 2012), which can only be displayed by applications that support the complex Adobe Imaging Model (Adobe, 2000).

DTBooks were specifically referenced by Rose et al. (2006) in their initial treatise of universal design for Learning (UDL) as a format for students with various levels of visual impairment as well as dyslexia and other cognitive disorders. DTBooks were intended to support UDL's requirement for *multiple means of presentation* to accommodate the various ways that students interact with and learn from courseware (Rose, 2006, p. 136). Accessibility advocates have suggested adoption of EPUB as the universally accessible replacement for DTBooks (DAISY Consortium, 2011) but their voices are struggling to be heard

in a world dominated by commercial purveyors of "accessible PDF." Progress is evident, however, in the growing number of publishers who have created academic databases containing EPUBs (e.g., ABC-CLIO, ACLS Humanities, EBSCO E-Books, Proquest's Ebrary, Elsevier's ScienceDirect, Taylor & Francis).

Review of Relevant Literature

Society's essentially unexamined embrace of PDF for document distribution is evidenced by a paucity of academic research on the ramifications of its adoption. In response, this study reviews literature that address motivation's role in technology adoption and the value of altruism as one facet of motivation, as well as the invisible nature of non-apparent disabilities, and what may be the only previous peer-reviewed research on student preference for EPUBs.

Foundational Thinking on Motivation

Sundaram, Mitra, and Webster's (1998) research on word-of-mouth communication was among the first to include altruism as a contributor to motivation, specifically defining it as "the act of doing something for others without anticipating any reward in return" (p. 529). Hernandez et al. (2011) reported on the significance of altruism in determining attitude towards and usage of Information and Communication Technology (ICT) tools. Their research found that participants in online courses were significantly motivated by altruistic feelings toward their classmates, even though the virtual nature of these courses diminished the likelihood that their altruistic behavior would be reciprocated (p. 2228). Kankanhalli et al. (2005) investigated the motivation of knowledge management practitioners and found that the intrinsic benefit of altruism was strongly correlated with the motivation to share knowledge (p. 131).

Disability Non-disclosure

The principal tenet of universal design, i.e., that the same version of a thing should be usable by everyone without regard to their abilities, becomes even more important when we consider how difficult it can be to identify which students are in need of accommodation. Kranke et al. (2013) found that "students with non-apparent disabilities encountered stigma from peers and professors" (p. 36), which creates pressure for students to maintain their undisclosed status whenever possible. Students identified a desire for autonomy and normality as additional reasons for avoiding disclosure, as well as concern about maintaining compliance with their professor's instructions to avoid undermining the professor's view of their capabilities (p. 43). Salzer et al. (2008) conducted a survey of students diagnosed with mental illness. A majority (56%) said they felt embarrassed when alerting professors to their disability and were fearful that these professors would stigmatize them (p. 373). Forty-two percent of students who had disclosed their condition characterized their professors as being unreceptive or even uncooperative (p. 373). These findings support the position that many non-apparent disabilities go unreported, strengthening the case for universally accessible texts as a way to obviate the need for student self-reporting.

Digital Texts in the Classroom

Literature on the use of self-contained, portable electronic document formats in the classroom (as opposed to HTML-based presentations) is in short supply; studies that compare multiple forms of electronic documents are rare. However, standalone archivable document formats deserve in-depth analysis because the format that emerges as our final choice will become the accepted replacement for printed class texts. Given the speed with which one-to-one allocation of laptops has swept through our schools, it seems unreasonable to think that physical books and paper will continue to be the primary option for academic enculturation. In today's post-secondary environment, smartphone compatibility has also become a key consideration.

In a rare peer-reviewed study involving e-book formats, Mills (2016) conducted a quasi-experimental test of student preference between a course textbook distributed in one of three e-book formats: PDF, KF8 (Amazon Kindle documents), and EPUB. Some students received an EPUB document, while others received either a PDF file or a KF8 (Kindle) file. Participants who received the EPUB file reported significantly higher levels of interaction and engagement with the course text, as well as greater perceptions of the text's usefulness and value (p. 130).

Methodology

Qualitative research was conducted to discover the actions and opinions generated when students without print disabilities were asked to interact with one document saved in both PDF and EPUB formats. Observation of these interactions and subjects' responses to semi-structured interview questions (Appendix A) were used to cast light on the current study's research questions.

Participants

Six undergraduate students (ages ranging from late teens through early 20s) from a small Midwestern university were interviewed; the sample consisted of

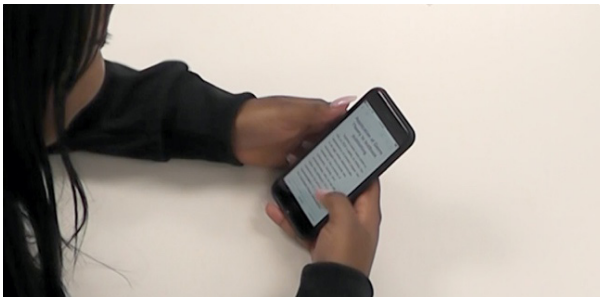
an even split between male and female participants; 50% were Black (one female, two male), and 50% were White (two female one male). Each student was enrolled in a different major: Accounting, Communications, Kinesiology, Nursing, Psychology, and Special Education. The participants comprised a convenience sample of former students from an on-line class taught by this study's principal investigator (PI) in a previous semester. Participation was incentivized through an offer of $15 cash, which was given out at the start of each session.

Procedures

Data were gathered during individual face-to-face interviews conducted within a small conference room on campus. The participants were asked to examine the same document in two different formats, PDF and EPUB, on whatever computing platform they preferred; three used a laptop, while the other three used a smartphone. Among the laptop users, two were running Microsoft's Windows operating system while one was running Apple's MacOS. All three smartphone users interacted with an Apple iPhone. While using these devices, the participants were asked to interact with the two documents in various ways: scrolling, reading, searching, navigating to a specific section, and enlarging the document's text (Appendix A, Part 2).

These interviews were recorded with a high-definition video camera placed behind the students' right shoulder to capture their hand movements as they interacted with an EPUB on their device of choice (Figure 1). These video recordings allowed close observation of students' interactions with the hardware and software used to access the documents, to note any challenges or general patterns that emerged from their use of these familiar and unfamiliar document formats. The soundtracks of these recordings were exported for manual transcription.

Figure 1. Still-frame image of participant interacting with an EPUB reading device.



Ethical Concerns

These students were invited to participate because they had some small familiarity with the idea of an EPUB file as a self-contained portable document format. They gained this knowledge by participating in an extra-credit assignment during a class taught by the current study's PI during the prior semester; each had earned extra credit by downloading one short EPUB file from the class Blackboard site then taking a short quiz about their interaction with the document. Upon reflection, these students' participation in the current research was deemed appropriate, as their experience could reduce the initial strangeness of the EPUB format thereby enabling a more accurate appraisal of their ability to interact with it. It was also likely apparent to these participants that their interviewer is an advocate for EPUBs within academia. However, there was no relationship between these students and the PI at the point when this research occurred, so the participants had no compelling reason to modify their behavior to gain the PI's favor. All these concerns were the subject of self-reflection for the researcher; these reflections sought to foster an impartial approach to this research while remaining cognizant of the potential for bias.

Instrument

Subjects were asked seven semi-structured questions at the onset of each interview, after which they were directed to interact with both an EPUB and a PDF on their device of choice. During this interaction, they were asked to read the first page from each document (which often required them to zoom in), navigate to the first paragraph of each document's third chapter, then search for a specific term in each book. Following these interactions, the subjects were asked three semi-structured follow-up questions regarding those experiences with each technology. Finally, an additional three semi-structured questions were posed regarding accessibility and universal design (Appendix A).

Analytic Approach

Audio of the interviews was transcribed via F5 Transcription Pro software then open coded using Nvivo 12. An initial pass through all six transcriptions produced 24 codes related to the theme of EPUB adoption. A second pass through the data led me to merge two codes then organize thirteen others as sub-codes. This resulted in a total of 16 top level codes that were separated into four categories (Table 1). Several of these were related to aspects of motivation (altruism, compliance, ease of use, convenience) while others applied to the hands-on tasks performed when using e-books (e.g., controlling text size, navigation, search/find), techniques for studying

(general challenges with reading texts, preferred study locations), and participants' awareness of (or personal connection to) the principles of universal design.

Results

The findings that resulted from these interactions have been organized thematically as responses to my research questions. Pseudonyms have been used to protect participant identities.

Findings regarding RQ1: What is participants' knowledge of the EPUB format?

EPUB remains largely unknown to students

Although these participants shared a past exposure to the existence of EPUB, they were unanimous in saying that they had not heard of the EPUB format prior to that extra-credit assignment, nor had they heard the term used since that initial exposure. However, two of the participants (Emma and Francine) stated that they were using Apple's iBooks software on their laptops, while Bernadette said that she sometimes used the iBooks app on her smartphone. This indicates an ongoing challenge for those who strive for greater awareness of the EPUB format within academia: software vendors have successfully branded the EPUB books sold on their e-book marketplaces with the name of their particular applications. EPUBs purchased through Apple's iBookstore are referred to as "iBooks" while EPUBs purchased through Barnes & Noble's marketplace are called "NookBooks." Even some academic publishers contribute to this lack of name awareness, e.g., the University of Chicago Press

Table 1. Nvivo codes for the theme of EPUB Adoption

Category	Codes	Sub-codes
Accessibility	universal design	Awareness of UD
		Personal connections to UD
Motivation	Altruism	Motivational aspects of altruism
		Unimportance of altruism
	Compliance	
	Convenience	Convenience of mobile use
	Ease of use	
Study techniques	Challenges with reading	
	Reading assignment formats	
	Study location preference	
	Technology for studying	Technology preference
		Technology problems
		Technology adoption
Using e-books	Awareness of EPUB	
	Choosing EPUB vs PDF	
	Comparing EPUB to PDF	
	Controlling text size	Enlarge text in EPUB
		Enlarge text in PDF
Using e-books	Genre of EPUB vs print books	
	Locating information in e-books	Search technique in EPUB
		Search technique in PDF
	Navigation	Navigation in EPUB
		Navigation in PDF

sends out a monthly email offering a "free e-book" but subscribers do not see the term EPUB in the initial email or the subsequent HTML landing page.

These branding issues result in a real problem for those who would encourage broader adoption of the EPUB format. Emma, owner of both an Apple laptop and an iPad, said, "I've used iBooks in the past, and I was aware that [the ability to change text size] was available." Her ability to modify font size when reading on her devices (rather than zoom in and out, as with a PDF) indicates that she must have had prior experience reading EPUBs – yet when asked earlier in the interview whether she had ever heard of EPUBs after the prior semester's extra-credit assignment, she said, "No." It will be difficult to build consensus around the advantages of the EPUB format unless users are able to identify this format by name.

Findings regarding RQ2: What challenges are reported or observed when participants access EPUB files?

Users report minimal challenges during EPUB adoption

To participate in the extra-credit assignment previously mentioned, each of the participants had already gone through the process of assuring that they could open and read an EPUB file. For three of the participants, this required no additional effort as they were already using Apple devices that ship with the pre-installed EPUB reader iBooks. Another participant also used pre-installed software to read his EPUB: Dominick, whose recently purchased Windows laptop included a version of Microsoft's Edge browser that could open EPUBs without a plug-in. The remaining Windows-using students reported that installation of the necessary free software to read EPUBs was unproblematic. When I asked Charles whether he thought that other students would find it too difficult to install an EPUB reader onto their preferred reading platform (e.g., laptop, desktop computer, tablet, smartphone), he responded: "I'm pretty sure students are used to being handed something new. Downloading it on their phone and getting used to it." However, a note of caution on this topic was sounded by Anton, who said:

> A lot of people are very lazy, don't like to do work anymore. They like a lot of work done for them the easy way and stuff like that, so I feel like it would be a complaint if stuff were harder and they had to put in more work. They would definitely complain.

This indicates the need for students to be motivated to download and use EPUB readers as part of their coursework, a topic that will be explored next.

Findings regarding RQ3: How do participants perceive EPUB's constraints and affordances?

Motivation through perceived ease of use and convenience

Videotaped observations of users interacting with both PDFs and EPUBs supported their overwhelmingly positive statements regarding EPUB's ease of use, but also yielded some unexpected results. It was surprising to discover these students' minimal knowledge of methods for interacting with PDF documents. Each denied that they had ever used bookmarks to navigate their way through a PDF, or even used the search function to locate a specific term within a PDF; similarly, none were familiar with the highlighting tool built into many PDF readers. As a result, students perceived greater ease of use for EPUBs about accomplishing several tasks associated with reading course texts: navigation, search/find, and adjusting text size for readability

Navigation is made easier by consistent access to a Table of Contents

One way in which EPUB is more consistently accessible than PDF is that EPUBs are required to make their contents navigable through any reading system's built-in Table of Contents menu (a feature not found in PDF reading systems, even when "accessible PDFs" are used). Often called the *hardware TOC*, this navigation system is immediately available in a consistent fashion from any page of any EPUB. Alternatively, EPUBs may also contain an *in-book TOC*, analogous to the Table of Contents page in a printed book (Figure 2). As with a PDF file that contains an in-book TOC, the chapters and sections listed might also function as clickable hyperlinks.

When asked to navigate to the "third section" of an EPUB viewed in Adobe Digital Editions (ADE) for Windows, Anton said he would scroll. Upon refamiliarizing himself with the fact that EPUBs change pages via a horizontal page-flipping convention rather than the vertical scrolling technique used by most PDF readers, he went to the EPUB's third page. Once he was informed that this was not the third *section* but rather the third *page*, Anton moved backwards through the pages until he found the in-book Table of Contents then

clicked on the appropriate hyperlink. Similarly, Dominick also used the in-book TOC hyperlinks to navigate to the third section when he viewed an EPUB with Microsoft's Edge web browser. When asked to locate the third section of an EPUB within the iBooks app on an iPhone, Francine initially swiped her way through two pages before deciding, without being prompted, to instead click on the icon for iBook's hardware TOC; this allowed her to very quickly reach the third section. The remaining users (Bernadette, Charles, and Emma) all selected the hardware TOC immediately upon being requested to navigate to the third section. Francine's explanation of her behavior was typical of all the participants who accessed the hardware TOC: "If you want to find a page, you just use this scroll thing, but yeah, if I wanted to find a chapter, I would just go to the Contents thing." Suspecting that the simple interface of an EPUB reader made it easy for the participants to recognize standard icon conventions (such as a Table of Contents), the PI engaged Charles in this dialog:

Interviewer: So show me how it was that you got to it. What was the method that you used? [Subject shows the built-in TOC menu.] Oh, so you went right into the navigation system!

Charles: Yeah.

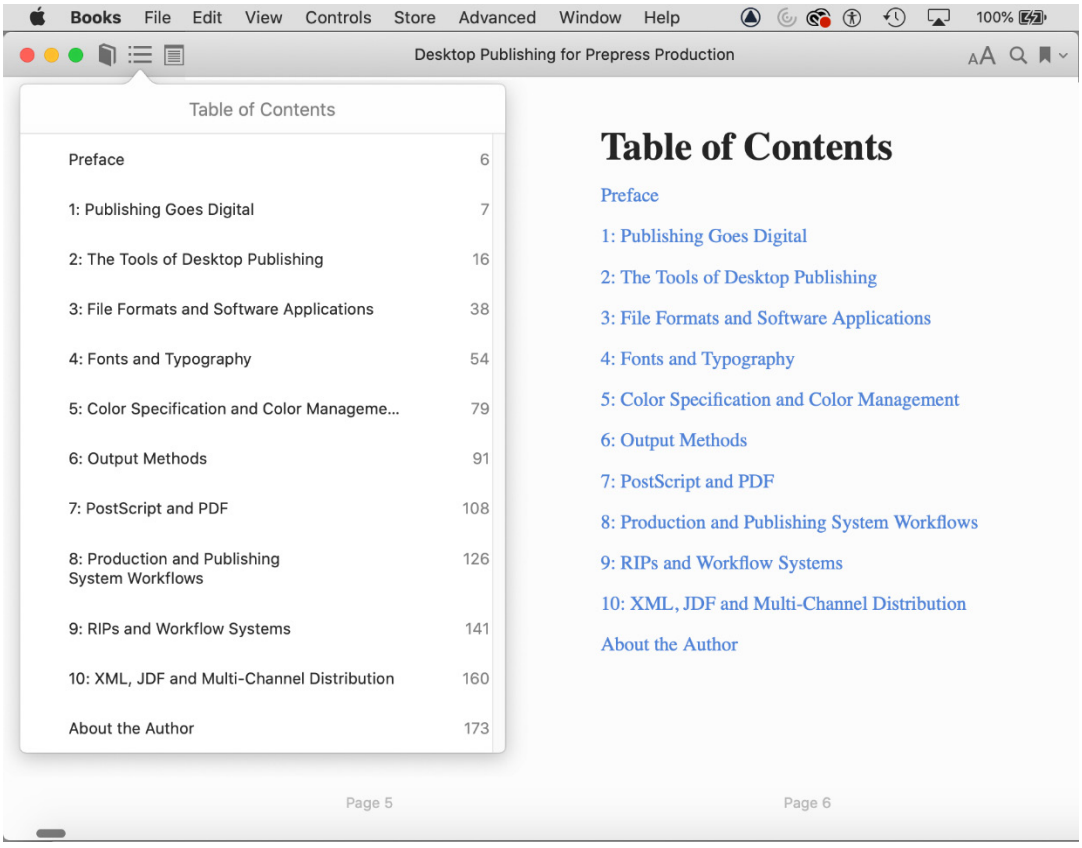
Interviewer: And so even though you'd never touched this phone before, or used that software before, it was intuitive that you could kind of tell that the thing up in the corner was an Index.

Charles: Yeah, it provides like a dropdown list or something.

Interviewer: Yeah, nice. Now are you familiar with seeing something like that in PDFs, or is there any kind of Index you use when you're going through PDFs?

Charles: Mmm, not that I can remember.

Figure 2. EPUB's hardware TOC (left) and in-book TOC (right).



The interviewees' ability to easily locate the hardware TOC within two different EPUB readers (Adobe Digital Editions and Apple iBooks) on three different platforms (a Windows laptop, a Mac laptop, and an iPhone) shows the value of a streamlined user experience that follows consistent user interface conventions.

Search capabilities may be underutilized

Surprisingly, all participants denied having knowledge of how to search for a specific term within a PDF file. Several knew the keyboard shortcut for search (control-F on a PC, command-F on a Mac), but only associated that process with web browsers. Each participant found it easy to search for a specified term within an EPUB. Dominick, the student who viewed his EPUB within the Microsoft Edge web browser, used the keyboard shortcut control-F to bring up the search function; the remaining interviewees were all able to quickly identify the magnifying glass icon that represented the EPUB reader's search function.

Enlarging text for readability is the key to usability on smartphones

While the laptop users in this study were not overly concerned with the size of displayed text, the smartphone-using participants were immediately challenged by the tiny size of text within PDFs. By default, PDF readers display the full width of the PDF; as a result, the text was rendered too small for students to read. When the smartphone users examined an EPUB on their mobile devices, they commented on the difference in readability. EPUB readers feature reflowable text that is not bound by a particular page geometry, so the default text size was consistently large enough to be readable. The participants also found it easy and intuitive to change the size of the displayed text by clicking the icon representing text size: two adjacent instances of a capital letter A, shown at different sizes. All interviewees conjectured about how the capability to control font size would increase the likelihood that they would use their smartphones to occasionally read assigned texts, especially during short breaks between classes or while traveling.

The convenience of being able to use a smartphone to read class texts was noted by all participants. As an example, Bernadette said: "With it being on your phone, you can change the font size to however large or small you need it. So, you can do the reading on the go, so you can get it done." Similarly, Dominick said: "I feel like EPUB on a cellphone would probably be a lot better than a PDF because once again, like I said, it's all blocks, blocks of text." (Dominick had complained that the vertically scrolling display of PDFs on his cellphone made them appear as dense blocks of text rather than paragraphs.) Charles specifically called out the convenience of EPUB's usability on his mobile device: "I look for convenience. So, I usually, if I can read it on my phone and get the job done, then I will."

Findings regarding RQ4: Does altruism motivate participants to adopt the EPUB format?

The current research found that students were more motivated to support EPUB adoption after learning that the format's accessibility is superior to that of PDF. It is important to note that none of the interviewees who participated in this research self-identified as having a learning disability, and that of these six undergraduates, only two were marginally familiar with the term universal design.

Altruism provides only limited motivation for technology adoption

Anton was among the majority who were unfamiliar with the concept, but he soon revealed that he was familiar with the inclusive practices enabled by universal design, noting that "We had, like, wheelchairs in our class, kids with disabilities in our class, so now it's like normal for us. Our generation, we're like used to it." He also saw the value of materials and practices that enabled inclusive learning and supported the idea that accessible materials would also be valued by his classmates: "It'd make everybody want to use [EPUB] more, since they'd know like okay, this isn't just for me, it's for other people too with disabilities and stuff like that." However, when asked how much additional difficulty the typical college undergraduate might tolerate when being asked to adopt a new accessible technology, Anton once again turned skeptical. "If it's more work, yeah, people will complain," he said, "I know my generation, a lot of people are lazy."

The two students who were already familiar with universal design supported Anton's view that the majority's largesse could not be taken for granted. Francine, a Psychology student who said that she was broadly familiar with the term universal design but had no knowledge of its applications, noted, "I wouldn't be more motivated to use [EPUBs due to accessibility] because I wouldn't need it, but for other reasons I would be, like the things I said earlier that attracted me to the EPUBs." Francine enjoyed the ability to change font sizes or switch to white text on a black background, as well as moving through documents by

swiping right-to-left rather than scrolling vertically. "But unfortunately," said Francine, "that universal design thing wouldn't motivate me personally to use it more." Like Anton, she felt that touting the direct benefits to users would be key in easing the adoption path for EPUB. In contrast to Anton's skepticism, though, Francine thought that there would be little resistance if teachers mandated the use of EPUB. "Obviously it would be beneficial to people that need it, whether or not I need it; so, I wouldn't care, personally," she said. "It was a small hurdle. No difficulty for me at all."

Personal connection to disability strengthens motivation for universal design adoption

To varying degrees, all participants saw the universal design aspect of EPUB as an advantage, but interviews revealed that a personal connection to this topic produced an even stronger connection that further reduced resistance to adoption of EPUB technology. Emma, a Special Education major who volunteered that she has "thought about this a lot," said that "the issue isn't whether or not it's fair, it's making sure everyone has the same learning abilities." Her responses were the most specific in this regard, but all the participants expressed some level of support for mainstreaming students with special needs into the general classroom population whenever possible. Bernadette, a second-year Nursing student, revealed that her familial relationship with disability has resulted in greater appreciation for the concept of universal design: "I think that helps make people more receptive to the idea [of using EPUB]. I come from a home with two brothers who are mentally impaired, so I know it sparks my interest," she revealed. "Because I know my brothers learn at different rates and one likes to read, the other doesn't like to read but likes to listen to things, so I think it would be, like, perfect."

Additional Findings

One emergent finding that was not anticipated by this study's research questions is the strong role of compliance on student motivation. As noted by Kranke et al. (2013), students are highly concerned with maintaining a favorable relationship with their instructors – or as Vroom (1964) might have positioned it, to avoid the pain of negative criticism. Although this topic was not directly addressed by any interview question, Emma echoed a sentiment that was consistently expressed to various degrees by all the other interviewees – that students would simply comply with the transition to a new technology (e.g., EPUB) if instructed to do so by their teacher:

> If I were to sit down, I came to [this university], I'm a freshman and my teacher – my professor – hands me an EPUB, well that's how I'm going to learn to read and I'm not going to question it. People are just going to get used to it and it's going to become the normal. Because it does have those features for people with special needs or learning disabilities and if they need them, they can have them. So, I don't think it's inconveniencing anyone, and I don't think many students would question it.

Some scholars might challenge Emma's statement by citing Activity Theory (Engestrom, 2000); under that premise, students who had operationalized the use of PDF should suffer discomfort when their zone of proximal development was de-centered by the introduction of EPUB (Vygotsky, 2011, p. 203). The current research, however, indicates that these twenty-first century learners have become accustomed to constant change in their selection and use of technological tools. Anton expressed confidence in his classmates' ability to implement the new software needed to read EPUBs, saying that "Everybody's technology savvy these days; everybody knows technology, so it's not really that hard to figure out."

Emma framed the introduction of new technologies and formats as the duty of the instructor: "I think it's important, especially with technology nowadays, that we're exposing students to that. Not to say textbooks aren't functional, but jobs nowadays will never hand you, 'Here's your [printed] manual.' They're gonna say, 'I'm going to e-mail you that manual.'" From Emma's point of view, the medium is clearly as important as the message: content wrapped in the trappings of print culture is seen as having less real-world relevance to today's technology-driven students.

Ranking the influence of these four motivational factors was a challenge. In the case of these six interviews, it would be unreasonable to use word frequency to judge the importance of each factor, as only some topics were emphasized in the semi-structured questions. The influence of altruism, i.e., whether the realization that EPUB supports a universal design approach to accessible instruction, was given the most emphasis in the questions yet produced the least emphatic responses; two of the six interviewees went so far as to say that they would not be more likely to support EPUB adoption on the basis on its superior accessibility. In contrast, the issue of compliance was not mentioned in the interview questions yet each of the six participants made

unprompted references to compliance as their primary motivational factor. Ease of use and convenience were both included in the interview questions, and both were unanimously supported by participant responses; between these, ease of use sparked more dialog but received less emphasis than compliance.

Discussion and Conclusion

This study examined the role of student motivation in the adoption of a new instructional technology, EPUB. An analysis of participants' statements and actions during the adoption process led to the identification of four positive motivational factors, listed in order of perceived importance: compliance, ease of use, convenience, and altruism.

Interviews revealed that any resistance from these able-bodied students towards the additional effort needed to implement EPUB, i.e., to learn new procedures and perhaps install new software, was somewhat reduced by their altruistic desire to participate in an accessible universal design pedagogy. Before this research was conducted, it was expected that participants might speak of altruism's connection to technology adoption as being more important than traditional motivational factors, e.g., learning goals and performance goals (Dweck & Leggett, 1988), but the statements and observed actions of the participants in this study caused a reevaluation of those initial expectations. The altruistic aspects of accessibility were eclipsed by EPUB's affordances for sighted users, e.g., ease of use and the convenience provided by EPUB's superior compatibility with smartphones. Above and beyond these factors, however, compliance emerged as the key motivational factor regarding these university students' willingness to adopt a new technology.

As predicted by Tooby and Cosmides (1996) "Banker's Paradox," if the cost to the individual is deemed low, then altruism becomes a permissible response. Altruism ranked fourth among the four positive factors driving the acceptance of EPUB technology among this set of undergraduates, which indicates that instructors should first point out the ways this new format can benefit the sighted, smartphone-wielding majority before touting EPUB as an accessible format that can benefit students with physical and cognitive disabilities.

These results have significance for the growing community of educator who have restructured their curriculums around the concept of Universal Design for Learning, as the EPUB format enables a universally accessible approach to the dissemination of course documents. Beyond practitioners of UDL, the EPUB format can be embraced by all educators desirous of truly inclusive pedagogies. The current research also has implications for the study of student technology adoption, as it supports Chen et al.'s (2017) extension of Davis' (1989) Technology Acceptance Model to include altruism. Additionally, it supports Kranke et al.'s (2013) conclusion that compliance is a powerful motivator of student behavior as well as Mills' (2016) recommendation of EPUB as a format well-suited for both sighted readers and users of assistive technologies. Such results can inform research into the adoption of other formats and technologies beyond EPUB.

While this small-scale exploratory study featured only a handful of participants in an interview setting, large-scale experimental studies should be conducted so that researchers can extrapolate their findings to a more generalized student population. Such additional research would also serve to expand the pool of available data on student technology preferences.

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Appendix A: Interview Guide

Part 1 interview questions:

1. Please tell me a little bit about the degree you're working towards.

2. What sort of technology do you use during your coursework?
   [Follow-up: Is that something you (or your family) own, or do you have to go to campus to get access to that technology?]

3. Describe your typical routine when you're asked to read a document for class.
   [Where does that reading take place? Is that how you prefer it, or is something/someone causing that?]

4. Typically, what form do those documents (that you've been asked to read) take? (Expected responses include web pages, PDFs, Word files, printed handouts, physical books.) [Is that always the case, or have you been given other types of documents?]

5. When it comes to reading texts for classes, what sorts of challenges do you face? [Any cognitive issues that affect your reading ability, such as dyslexia or ADHD?]

6. If you could design an ideal way to do your course readings, what would it be like?

7. What do you know about the EPUB document format? [Get the person to talk about their experience in ETT 229, then ask if they had any prior experience with EPUBs.]

Part 2 (observation):

Ask the student to use their preferred platform for reading digital texts (either their laptop or smartphone; I can also have a desktop PC or Mac available if they identify that as their preferred device). Videotape their actions so you can check the amount of time needed to perform tasks, as well as their general comfort level. Tasks to have them perform:

- Read the first page from two similar e-books, with the first in PDF format and the second in EPUB format.

- Navigate to the first paragraph of each document's third chapter to find a quote.

- Look up a specific term in each book's Index.

Part 3 (post-observation) interview questions:

8. How did your experience reading an EPUB differ from using a PDF?

9. If you were in a class next semester that used EPUBs for the course readings, how would that affect you as a student? [Get them to discuss both pros and cons. If necessary, ask them if the PDF seems more "formal" or "authoritative."]

10. If you were searching for an article in NIU's online library and that article was available in both PDF and EPUB formats, which would you choose and why?

Part 4 (on accessibility):

First, explain the difference between "accommodation" and universal design. Then, describe the way that accessible texts that can work with assistive technologies (e.g., screen readers and braille terminals) to help meet universal design goals. Follow with a few closing questions:

11. What do you know about universal design? (What do you think about it?)

12. Do you think that universal design sounds like a good idea, or should students who need accommodations be offered special documents, or even be placed in courses that are separate from the mainstream? Why or why not?

[If the subject is pro-UD, ask: "Do you feel that schools should use books and materials that are as accessible as possible, even if that choice is sometimes inconvenient for the majority? How much inconvenience should the majority be willing to tolerate?"]

Exploring Web-Based Tutorials for Differentiated Learning in Higher Education

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Abstract

Instructors in graphic communications and design courses are often expected to teach both soft design (principles and theories) and hard design (technical skills in applications), which can be a difficult balance within the classroom setting. Now, more than ever, due to shifting toward online or blended learning solutions caused by the pandemic, technology needs to be used effectively for teaching online asynchronously. Enhancing digital literacy for content creation involving the instruction of creative software in the discipline of graphic communications is essential in the education of undergraduate students. Because students enter college at varying levels of computer literacy, there is difficultly in meeting the range of needs. Such needs include helping students with basic technical skills, while also having the rigor to challenge students with more advanced technology skills. This study explores the effect that differentiated web-based tutorials may have on student self-efficacy and engagement in a higher education graphic communications lab. Findings revealed that both student self-efficacy and engagement increased with the differentiated tutorials. This research may be helpful to university graphic communications programs looking for a blend of design technology resources to open up opportunities for a more promising and engaging student learning experience.

Keywords: differentiated instruction, self-efficacy, student engagement, technology identity

Today's higher education students are digitally inclined but not necessarily digitally literate. In response to the unprecedented pandemic, it is crucial to consider effective measures of online instruction. With numerous resources available, instructors of graphic communications courses are faced with how to balance technology tools in the computer laboratory with printing technology in the adjacent laboratories. In graphic communications, there are several laboratories that prepare students for industry with various design and prepress applications. In 2019, the Graphic Communication department was the first department at California Polytechnic University to grant student access to LinkedIn Learning (previously lynda.com), an online learning website offering courses taught by experts in various industries. There are varying opinions regarding how frequently these web-based courses should be used; from completely relying on the courses for teaching basic software skills in all the applications, to being used only as supplementary resources to assist students who need more outside instruction. This research focused on what impact differentiated web-based tutorials have on student self-efficacy and engagement in a higher education graphic communication course.

With more online tutorials available, it gives more potential for direct student growth, while also impacting the role of the instructor. As pointed out in the 2017 Higher Education NMC Horizon Report, "educators are no longer the sole authoritative source of information and are expected to assist students in navigating the mastery of content and skills" (Becker et al., 2017, p. 34). By allocating time for students to learn hard-skills via web-based tutorials, university faculty may have more time in their face-to-face classes for the application of soft design skills (Wadhwa, 2013). This study explores how differentiated web-based tutorials, specifically LinkedIn Learning, may be effectively implemented in graphic communication design labs.

Literature Review

Technology Identity and Self-Efficacy

Students come into a learning environment with a technology identity, which includes: 1) how they perceive their tech skills, 2) the value they place on technology, opportunities and hindrances, and 3) their belief about motivation toward technology (Goodyear & Retalis, 2010). Their technological identity is found to make a difference in their performance with technology (Goode, 2010). Students from different socio-economic backgrounds have varying access to technology—formally and informally—and differ in their use of technology (Goodyear & Retalis, 2010) These varying backgrounds contribute to the forming of technology identity and is a factor in the current digital divide of students entering into higher education (Goodyear & Retalis, 2010). Considering the context of technological background requires a mindset beyond a deterministic approach toward teaching (Goodyear & Retalis, 2010).

Technology identity molds a student's computer self-efficacy — what they believe they are capable of accomplishing in computer-related tasks (Compeau & Higgins, 1995). Dames (2016) conducted a study, using Compeau and Higgins computer self-efficacy scale with students in a graphics-related course to see what could potentially improve their computer self-efficacy. Due to students' lack of graphics experience and noting Bandura's (1986) findings that self-efficacy is most influenced by challenging and unfamiliar tasks, Dames (2016) set out to address this concern in the area of graphic skills acquisition, specifically Adobe Photoshop. She found that there was an increase in computer self-efficacy when students were challenged with new ways of using tools within the software program and when they were given chances to work independently after behavior modeling (Dames, 2016).

Student Engagement

An important component to digital technology in the classroom is the level of student engagement that occurs with various approaches. Student engagement may be defined as "the extent to which they take part in educationally effective practices" (Carini et al., 2006, p.31). Student engagement is often linked with academic performance and is one of the best ways to determine the depth of learning and student development (Carini et al., 2006). Research by Twigg (2005) has shown that courses with added instructional technology, such as instructional software and web-based learning, encourage active learning and become more student centered. And using technology may "increase the opportunities to stimulate higher order levels of thinking" (Robinson & Hullinger, 2008, p. 103).

Differentiated Instruction

With the varied levels of computer experience, self-efficacy, and technology identities, differences need to be addressed using alternate educational approaches. It would be far reaching to resolve these differences using traditional methods of "single-size instruction" (Tomlinson, 2001, p.2). Differentiated instruction aims to provide "varying activities, techniques, and teaching strategies to help learners make sense of meaning and understand underlying principles" with a focus on "student readiness" and not on learning styles,

due to the lack of scientific evidence backing the latter (Pham, 2012, p.16). Traditional teaching to "the middle" leaves students with basic skills struggling while the students with more advanced skills remaining unchallenged (Wu, 2013, p.126). Tomlinson pointed out that the approach of teaching only one element at any given time can miss nearly everyone (Wu, 2013). The need for differentiation in higher education has only increased with the rise in diversity among student learning communities (Jackson & Evans, 2017).

Although research regarding differentiation in K-12 is prevalent, it is limited for higher education (Jackson & Evans, 2017). Lightweis (2013) compiled research on higher education differentiation practices and found that all studies had positive results in student learning, often as a result of faculty support. Faculty support included a variety of options for student-centered lessons, activities, materials, and resources (Lightweis, 2013). Differentiated instruction would require a shift in instructor role, from "administrators of learning" to "consultants" and "facilitators" that use constructivist practices for student-centered learning (Jackson & Evans, 2017, p.10). There is little support for college instructors in making this transition and the requirement for planning differentiated instruction greatly increases workload (Jackson & Evans, 2017).

Methodology

The purpose of the study is to determine the impact of web-based scaffolding (resources/materials) for learning design software among students entering the course with varying skill levels. The impact of creating access to a differentiated blend of web-based courses, specifically LinkedIn Learning, was examined and the effect on student engagement and perception was assessed. Differentiated instruction for all skill levels was introduced to improve students' digital literacy in specific Adobe design programs. Since this was the first computer laboratory taken by first-year Graphic Communication students, it was essential that a strong foundation was established with commonly used software applications.

Intervention

In this unit of instruction, students were introduced to Adobe Illustrator and Photoshop in two-week sessions. Two weeks were spent learning Illustrator and two weeks were spent learning Photoshop, totaling four weeks. Each introductory lab took students through the software's workspace, essential tools, example work, tips and most frequently used key commands. A hands-on software project was completed in each lab, with instructor guidance as scaffolding; then students were given a project to complete outside of the lab session that utilized the software basics and tools they learned to help them apply, practice, and refine their skills.

Two groups were studied, a control group and a treatment group. The difference between the control group and treatment group was that after the introductory week for each software, the treatment group received recommended paths of differentiated tutorials requiring varying skill levels that they were able to choose from, compared to the single tutorial that the control group was given. These tutorials were required to be viewed outside of lab prior to completing their projects. Three lab sections were studied, ranging from 16 to 20 students. The section 03 lab (19 students) was the control group that received only one tutorial and project. The other two labs, section 02 and 04 (37 students) were the treatment group that received differentiated tutorials and projects from which to choose. A quasi-experimental design was chosen due to the fact there was not the ability to have a randomized sample. This approach allowed for an independent variable, the differentiated web-based tutorials, to be given to the treatment group and compared to the control group. The University's human-subjects research process was followed.

Site Context and Participants

Intervention and data collection took place in Fall 2019. Half of the admitted cohort were part of this study as their first graphic communications course. Students' initial skill sets ranged from no use of design programs to moderate use, up to high proficiencies with the applications. When self-assessing their prior skill level in Adobe Illustrator, 10% of the incoming students stated they had never used the program, 20% had opened the program but didn't know how to use the program effectively, 30% had a little exposure to the content and believed they could do simple graphics with tools in the program, and 40% claimed they could create high end vector graphics, which students attributed to exposure in high school elective design classes or extra-curricular activities such as yearbook.

Data Collection and Analysis

A mixed methods experiment measured quantitative and qualitative data in the form of a pre-postsurvey. The survey gathered quantitative data at the end of the learning unit to determine the change in computer software self-efficacy and reflect on experiences through Likert-scale questions and open-ended questions. Quantitative data was used to conduct paired samples t-tests that compared treatment vs. control for the Likert-scale efficacy

retrospective pre-post survey. Surveys were administered digitally through Google Forms.

Findings

Student Self-Efficacy

The pre-post Likert survey showed the perceived confidence levels for each software program. Students ranked their confidence for where they felt before taking the software tutorials and then after completing the software tutorials and corresponding project. These confidence levels were coded as no confidence (1), slight confidence (2), moderate confidence (3), and high confidence (4).

Self-efficacy: Adobe Photoshop and Adobe Illustrator

The results for the control group for Adobe Photoshop, those with a single learning tutorial, showed an overall increase in confidence. The average change in confidence for the control group was an increase of 0.94. The average change in confidence for the treatment group was an increase of 1.35. A Paired T-Test was administered to find evidence of a statistically significant difference between students' confidence before compared to after the Adobe Photoshop labs. There was a statistically significant difference in the control group Adobe Photoshop confidence scores for before (M=1.89, SD=.96) and after (M=2.83, SD=.62) conditions; t(17)=-5.52, p=0.000 (Table 1). These results suggest that confidence levels in the control group were positively increased after taking Adobe Photoshop in 201 lab.

There was a statistically significant difference in the treatment group Adobe Photoshop – those with choice in their learning path based on skill level – with confidence scores for before (M=1.73, SD=.84) and after (M=3.08, SD=.68) conditions; t(36)=-10.41, p=0.000 (Table 1). These results suggest that confidence levels in the treatment group were positively increased after taking Adobe Photoshop in the lab. The treatment group showed a greater increase in confidence scores than the control group when comparing pre-post survey results.

The results for the control group for Adobe Illustrator show an overall increase in confidence. The average change in confidence for the control group was an increase of 1.31. And the results for the treatment group for Adobe Illustrator also show an overall increase in confidence. The average change in confidence for the control group was an increase of 1.22. The comparison between the average change in confidence for control group and treatment group show that the control group had a greater change in Adobe Illustrator confidence.

A Paired T-Test was administered to find evidence of a statistically significant difference between students' confidence before compared to after the Illustrator labs. There was a statistically significant difference in the control group Adobe Illustrator confidence scores for before (M=1.88, SD=1.09) and after (M=3.19, SD=.66) conditions; t(16)=-6.01, p=0.000 (Table 2). These results suggest that confidence levels in the control group were positively increased after the Illustrator labs. There was a statistically significant difference in the treatment group Adobe Illustrator confidence scores for before (M=1.98, SD=.88) and after (M=3.11, SD=.57) conditions; t(36)=-11.75, p=0.000 (Table 2). These results suggest that confidence levels in the treatment group were also positively increased after the Illustrator labs.

Student Engagement

To answer the question regarding student engagement, upon completion of the Adobe Illustrator and Adobe Photoshop LinkedIn Learning labs, students from the control and treatment groups answered Likert survey questions pertaining to LinkedIn Learning. They also answered open-ended questions. When asked about LinkedIn Learning software tutorials (see Figure 1 and Figure 2), 47.4% of the control

Table 1. Paired Samples Test for Photoshop Before/After for Treatment and Control Groups

					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	T_beforePS_Numeric - T_afterPS_numeric	-1.35	.78	.13	-1.61	-1.09	-10.41	36	.000
Pair 2	C_beforePS_Numeric - C_afterPS_numeric	-.94	.72	.17	-1.30	-.58	-5.52	17	.000

Table 2. Paired Samples Test for Illustrator Before/After for Treatment and Control Groups

					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	T_beforeAI_Numeric - T_afterAI_numeric	-1.21	0.63	0.10	-1.43	-1.00	-11.75	36	.000
Pair 2	C_beforeAI_Numeric - C_afterAI_numeric	-1.31	0.87	0.22	-1.78	-.85	-6.01	15	.000

group responded that they did enjoy using LinkedIn Learning whereas the treatment group responded 81.1% favorably. In the open-ended questions, students responded to what they liked most about the LinkedIn Learning tutorials and what specifically they liked about it. Both the treatment and control groups appreciated the organization and detail of the tutorials. The greatest difference between the comments for the control versus treatment groups was the mention of choice of tutorials. Since only the treatment group received a choice, it makes sense that the control group would not have these statements.

Student Perception of Enhancement for Learning

The majority of participants in both the control and treatment groups responded that they felt the tutorials enhanced their learning of Adobe Illustrator and Adobe Photoshop, with the control group responding with 72.3% and treatment group with 91.9%. A representative comment from a student in the treatment group stated, "(Tutorials) helped to teach me new things about Adobe programs I did not know before." A quote from a student in the control group said, "As a visual learner, the video format made it much easier to learn and then apply the skills and tools directly to my own work." There was a large contrast between the control and treatment group's reactions to the experience of accomplishing these tutorials outside of class. Half (50%) of the control group said it was a good experience and 25% disagreed (Figure 3). Whereas 83.3% of the treatment group agreed and only 8.3% disagreed (Figure 4). Both the control and treatment groups mentioned challenges with length and tutorials that were too specific.

Figure 1. *Control group response to statement: I enjoyed using LinkedIn Learning software tutorials for this class.*

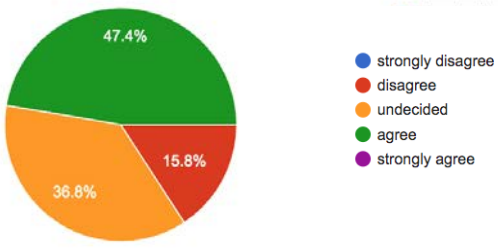
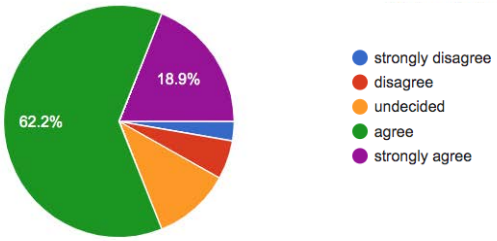


Figure 2. *Treatment group response to statement: I enjoyed using LinkedIn Learning software tutorials for this class.*



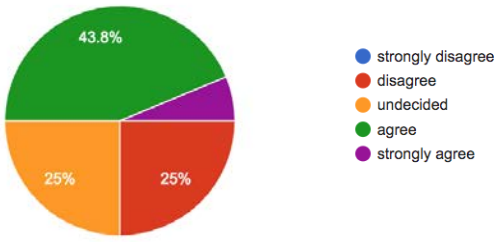
Discussion

The research results affirm that students who received the differentiated tutorials were more engaged and had a higher positive response about enhancing their learning. Differentiation may have an impact on self-efficacy. These results and implications are discussed below.

Online Tutorials as a Tool for Bolstering Students' Computer Graphics Self-Efficacy

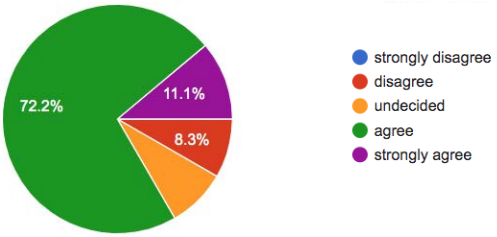
The results of the pre-post survey showed a slight increase in self-efficacy for both the control and treatment groups. It was anticipated that the statistical

Figure 3. *Control group response to statement: Working with the tutorials outside of class was a good experience.*



analysis would reveal a greater overall increase in self-efficacy in the treatment group compared to the control group due to the treatment group's ability to choose tutorials and which project to complete. This was accurate for the Adobe Photoshop self-efficacy results, as the treatment group did have a slightly greater increase. But for Adobe Illustrator, the control group actually had the slightly greater increase. The sample size may not have been large enough to produce accurate results, since the control group size was only 18 students while the treatment group was comprised of 37. Environmental factors may also play a role in forming students' self-efficacy.

Figure 4. Treatment group response to statement: Working with the tutorials outside of class was a good experience.



Another possible reason for similar self-efficacy scores between the control and treatment groups could be related to the lab instruction providing the same software behavior modeling to each group. This gave each lab a level of confidence before the requirement of watching the tutorials and doing a second project in each program. This result is also seen in Dames (2016) research, where she found that students had significantly higher levels of confidence after watching the instructor's live demonstrations in class. In Bandura's (1986) Social Cognitivist Theory, behavior modeling impacted a person's belief in how confident they were in completing a task.

Bandura et al. (1977) also discussed how self-efficacy can be raised or lowered based on comparison. Participants were exposed to other students' lab projects and it would be natural for them to compare what they saw as peer success or lack-thereof, impacting their personal efficacy. All students in the control group had similar projects since they all watched the same tutorial and completed the same project. Students in the treatment group had the potential of seeing 13 alternative projects, ranging from low to high skill. Students may have seen the highly skilled results of their peers which negatively affected their confidence in their own skill-level. This may be why the treatment group had a smaller change in self-efficacy in Adobe Illustrator. The projects in Adobe Illustrator start from scratch, whereas Adobe Photoshop work often starts with a preexisting photo. The range of skill is more easily deciphered in their Illustrator project in contrast to their Photoshop project.

Differentiated Online Tutorials May Allow for Greater Student Engagement

Students who had the differentiated options in LinkedIn Learning tutorials had a more positive response to the use of online tutorials than the students who only had one option. Over 90% of the treatment group agreed that the tutorials helped enhance their learning of the software programs. Offering a differentiated array of tutorials that ranged in skill provided an environment that demonstrated three of the seven areas of effective educational practices, as identified by the seminal work of Chickering and Gamson (1989): active learning, high expectations, and respect for diverse talents and ways of learning. Students found themselves faced with higher expectations as the choice for tutorials ranged in skills and could better match their perceived skill level. One student was extremely interested in the fashion industry and was inspired to choose the tutorial that had to do with fashion design. The tutorial was at a higher skill level than her initial assessment, but she still chose it because even though it was harder, it was a topic of deep interest. Many of the tutorials had diverse topics that allowed for students to connect and become inspired to learn in an area of greater interest than others.

Further Research

This research was designed to provide insight on differentiated web-based tutorials and their impact in higher education, specifically in the discipline of graphic communication. Further research should be conducted in the area of online tutorial evaluation. LinkedIn Learning is a popular resource and used for this research but it may not be the optimal source for online tutorials. Other sources should be considered and tested. Additional research on graphic skills assessment may provide a better benchmark for measuring student skill levels and determining the impact that differentiated tutorials have on growth in design skills. In light of the printing focus in graphic communications, another area of study could be the use of press simulators as a virtual option for laboratory instruction.

Resources

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Effect of Gloss Levels on Color Measurement of Printed Materials

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Abstract

Accurate color is very important in the printing profession. Clients expect their brand colors to be reproduced consistently and to specification. This can be challenging when printing across a variety of substrates, and in particular, substrates with high reflectivity such as gloss varnishes and metalized materials. Effective color management throughout the workflow is necessary. The use of spectrophotometers to read color values is commonly used.

This study examines how varying gloss levels in print impact color measurement. The experiment uses two different devices to measure two different color samples with varying gloss levels. The X-Rite 500 is a conventional spectrophotometer; and the X-Rite SP60 is a sphere spectrophotometer. Mean comparison of values by device was conducted using Tukey-Kramer's HSD and mean L* to determine the accuracy of the color value with differing gloss levels.

Two paint samples from the local home improvement store with varying gloss levels were measured in this experiment—a lighter beige and a dark blue. Data showed there was a significant difference in L* values read as gloss level increased, though to a lesser degree in when using the specular included (SPIN) mode of the spherical instrument. Interestingly, it was more evident in the darker blue color than the lighter beige, perhaps as a result of greater spectral reflectivity from dark backgrounds. The use of a sphere spectrophotometer in this experiment allowed the measurement of color while compensating for the gloss appearance in the specular included (SPIN) measurement geometry. Though the color values measured across gloss values were much closer, they still produced significantly different results.

Keywords: Color Management, Color Measurement, Gloss, UV Coating, Varnish

Introduction

Reproducing accurate color is an important factor in the printing profession. Companies expect accurate printing of their brand colors for products and marketing materials. The psychology associated with brand color connection to consumers is well-known, and when brands reproduce materials on a variety of substrates (i.e. direct mail, packaging, labeling, etc) and those branded colors are not accurate or consistent to the human eye, consumers can infer a quality concern with the brand. The use of specialty printing techniques such as gloss, matte and UV varnishes adds to the complexity in achieving consistent color in the printing process.

To better understand the term "gloss", we look to the CIE (Commission Internationale de l'Elcairage) definition: Gloss "as a mode of appearance by which reflected highlights of objects are perceived as superimposed on the surface due to the directionally selective properties of that surface" (n.d.-b).

The research for this project examines how varying gloss appearances affect the measurement of color. Two different color swatches with varying surface reflections (i.e. gloss) were selected and measured to determine if gloss impacts color measurement.

Two commercially available instruments were used to measure color in this study:
X-Rite 500
X-Rite SP60

Purpose of the study

The purpose of this research is to determine if varying gloss levels affect color measurement and in what way. The use of gloss and matte varnishes on printed materials to protect designs or as design elements changes specular reflection. If this change in gloss level affects the color value read by measurement devices, it can be a challenge to match printed pieces of varying specular reflection.

Hypotheses developed in this research:

H1: As gloss level increases, mean L* values will increase in SPIN measurement geometry.

H2: As gloss level increases, mean L* values will remain consistent.

H3: As gloss level increases, both instruments will have similar mean a* and b* values.

Review of related literature

This study looks at how the gloss level of printed material influences color measurement. Transparent varnishes, gloss or matte are used in various ways when printing. One application is applying a flood coat on the top of a printed image to protect the surface, another is for an optical aesthetic appearance that is applied as a design element, often called a spot varnish. Protective flood coatings are applied over an entire image, while for aesthetic effects only parts of the image may receive the varnish.

Glossmeter and Spectrophotometer

Although this study does not measure gloss, it is important to recognize how the visual appearance of gloss is classified. In 1937, Richard S. Hunter classified six visual criteria used to evaluate gloss: (Leloup et al., 2014, p. 562)

Specular gloss—related to the perceived shininess or brilliance of highlights;

Contrast gloss (or luster)—associated with the observed contrast between the specular highlights and the diffusely reflecting surface areas;

Sheen—describing the perceived gloss at grazing angles of otherwise matte surfaces;

Absence-of-bloom gloss or haze—related to the presence of haze or a milky appearance adjacent to reflected highlights;

Distinctness-of-image (DOI) gloss—perceived distinctness and sharpness of the observed mirror image after reflection from the surface;

Surface-uniformity gloss—associated with the perceived surface smoothness and freedom from visible nonuniformities such as texture or orange peel.

Gloss is evaluated by measuring the amount of specular reflection using a glossmeter. When measuring gloss with a glossmeter, the angle of viewing is always equal to, and opposite to the angle of incident. "The instrument is designed to yield numbers that correlate with visual observations of surface shininess made at roughly the same angles" (Leloup et al., 2014). The angle of incidence and viewing of about 75 degrees is used as a reference standard by the Technical Association of Pulp and Paper Industry (TAPPI). This standard is still in use today "because it allowed for the best selectivity regarding the gloss of coated book papers" (Leloup et al., 2014).

Hunter made key contributions to the standardization of gloss measurements. He designed a glossmeter with a 45 degree geometry. After the visual evaluation of a large number of painted samples, he concluded that a 60 degree geometry provided the best overall correlation with visual rankings (Leloup et al., 2014). In 1939, the American Society for Testing and Materials (ASTM) adopted the 60 degree geometry (ASTM method D523). Two alternative measurement procedures were incorporated into ASTM D523 in 1951:17 (Leloup et al., 2014)

These two measurement procedures are:
(as cited in Leloup et al., 2014, p. 562)

A 20 degree geometry test method for the evaluation of high gloss finishes,

An 85 degree geometry test method for the evaluation of low gloss surfaces.

While the above geometries are still widely used in the paper coatings industry, the color measurement community adopted slight variations on these measurement geometries. Color measurements in this study used a spectrophotometer for color measurement. "A spectrophotometer measures the spectrum of a sample, reporting the reflectance. The spectrum is the most complete descriptor of a color and can be used to calculate other color metrics such as L*a*b*" (Sharma, 2018, p. 97). The measurement geometry used for most spectrophotometers is 45˚/0˚.

As shown in Figure 1, The light source reflects at 0 degrees from the surface of the sample measured, and the detector receives reflected light at 45 degrees (Rosales, para. 4). However, in this research the Xrite SP60 sphere spectrophotometer was also used, which has an 8° geometry. A sphere spectrophotometer does not directly light the surface, instead it diffuses the light source. As shown in Figure 2, the color sample and gloss angle are viewed at 8° from perpendicular (Mouw, 1995).

Figure 1. 45˚/0˚ Geometry (Mouw, 1995, p. 1)

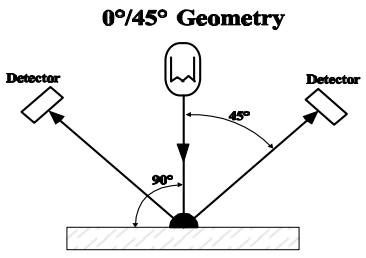
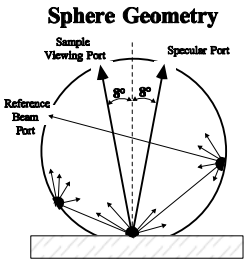


Figure 2 Sphere Geometry (Mouw, 1995, p. 2)



Spherical spectrophotometers measure reflectance two ways, specular excluded (SPEX) and specular included (SPIN). "A specular included reading includes the specular or gloss component, and a specular excluded reading excludes the specular or gloss component" (Mouw, 1995, p. 2). Specular included (SPIN) is preferred for measuring high-reflective surfaces and corrects for the specular reflectance influence on color, particularly in relation to L*.

Readings were collected using both excluded and included settings with this experiment. It should be noted that a 0°/45° instrument is only capable of specular excluded readings, while spherical instruments can read both specular included and specular excluded. (Mouw, 1995, p. 2).

A calibration tile is included with spectrophotometers to ensure accurate and repeatable color readings by resetting the instrument's zero-point. Both spectrophotometers used in this experiment were calibrated prior to measuring color data.

The standard observer angle is used in instruments to mimic how we visually assess color (Understanding Standard Observers, n.d.). The International Organization for Standard (ISO) 13655:2017 specifies the 2˚ observer angle because it more closely matches how printed material is viewed (International Organization for Standardization, 2017). All instruments were set to the 2˚ observer angle.

The CIE defines the standard illuminants used in colorimetry. These are used to "compute the tristimulus values of reflected or transmitted object colors under specified conditions of illumination" (Colorimetric Illuminants, n.d.). The D50 standard was used for all devices in this experiment.

Aperture is the size of the optic that reads the color swatch. Light travels through this optic to capture the color values. A larger aperture reads a larger area of the color sample. It should be noted that the aperture size

for each device used in this experiment varies. Aperture sizes for each device are shown in Table 1 below.

Table 1. Aperture size of each device

Device	*Aperture size*
X-Rite SP60	4.0 mm
X-Rite 500	3.4 mm

Delta E

Delta E (DE) is a formula developed to quantify the difference between two colors. A large Delta E means the human eye will see the colors as distinctly different, and a small Delta E would mean the colors look visually similar. This number allows us to easily determine if the color is within specification. Calculating Delta E is a single value calculated from the differences in measurement values of L*, a* and b*, frequently with mathematical tolerancing applied to more closely mimic human perception.

The CIE Delta E 2000 equation was used for this experiment to examine the differences of gloss color samples by each of the instruments. The low reflective Flat sheen sample values were used as the reference when determining Delta E. Mean L* is used to focus in on the impact gloss values have on L* specifically. These equations give a realistic understanding on the perceived color difference from specification.

Research Methods

Similar to the printing industry, the paint industry produces paints of varying gloss levels, known as sheen. Since paint gloss samples are readily available in most paint stores, paint samples of varying gloss levels were used for this study. This research is limited to coated substrates. Samples that were spectrally flat were preferred to look specifically at the L* values, but was limited to the colors available at the local home improvement store. Two gloss ramps were measured in this experiment. The darker color swatch in Figure 3 was from Behr Paint named "Midnight Blue" and the lighter swatch shown in Figure 4 was "Whiskers" from PPG Paints. "Whiskers" has four different sheen levels on the sample. Flat, Eggshell, Satin, and Semi-Gloss. "Midnight Blue" has six levels of sheen. Flat, Matte, Eggshell, Satin, Semi-Gloss, and Hi-Gloss. All samples were measured with a white backing by each instrument noted in the introduction. Care was taken to measure the center of each swatch for consistent readings across all devices. All devices were placed and not moved for the duration of the ten measurements. The X-Rite's clamshell design requires the device to be opened and closed for each reading, resulting in potential minimal target movement.

Both spectrophotometers were calibrated prior to color measurement using their supplied white tile. All measurements were read within a two-day period.

The X-Rite 500 spectrophotometer settings used were CIELAB, D50 illuminant, 2° observer angle, and 45°/0° geometry.

The X-Rite SP60 spherical spectrophotometer was set to CIELAB, D50 illuminant, 2° observer angle, and 8° geometry.

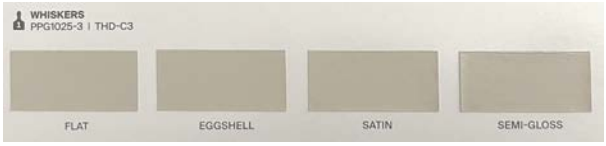
Ten swatches from two different paint gloss ramps (as shown in Figures 3 and 4) were measured ten times each, with minimal or no movement of the measuring instrument. The swatches were:

- Behr "Midnight Blue" (Figure 3)
  Flat, Matte, Eggshell, Satin, Semi-Gloss, and Hi-Gloss

- PPG "Whiskers" (Figure 4)
  Flat, Eggshell, Satin, and Semi-Gloss

Figure 3. Midnight Blue gloss ramp

Figure 4. Whiskers gloss ramp



An experimental study was designed to test these hypotheses:

H1: As gloss level increases, mean L* values will increase in SPIN measurement geometry.

H2: As gloss level increases, mean L* values will remain consistent.

H3: As gloss level increases, both instruments will have similar mean a* and b* values.

The X-Rite devices measured L*a*b* values and were recorded for all readings. Standard deviation and Delta E 2000 values were computed for each device by color and sheen.

Delta E 2000 was calculated using each color's sampled Flat value as the reference. This shows the difference in color as sheen increases.

An Analysis of Variance (Anova) and comparison analysis using Tukey's HSD (honestly significant difference) were run to determine if differences in numbers were statistically significant or a result of chance. The All Pairs, Tukey's HSD test performs significance tests of all combinations of pairs. Graphically, the comparison circles become larger and differences are less significant. Tukey's HSD is a t-test that corrects for family-wise error as follows:

Tukey's HSD formula

$$q_s = \frac{Y_A - Y_B}{SE}$$

Where YA is the larger of the two means, YB is the smaller of the two means and SE is the standard error of the sum of the means. qs is then compared to a q value from the studentized range distribution to determine if the difference is statistically significant.

Findings

Ten L*a*b* measurements were read and collected from each color sample and sheen level for each instrument. The resulting measured averages are shown in Table 2.

JMP® Pro 15.2.1 was used to compare the statistical differences in mean L*a*b* values. When comparing each device's mean L* readings among all sheens, the X-Rite 500 showed significant differences between Whiskers and Midnight Blue L* values among all gloss levels at α=0.05 confirming with a 95% confidence level that those differences were statistically significant. The X-Rite SP60 SPEX and SPIN had values that were statistically insignificant with a p-value above .05 for some of the sheen levels

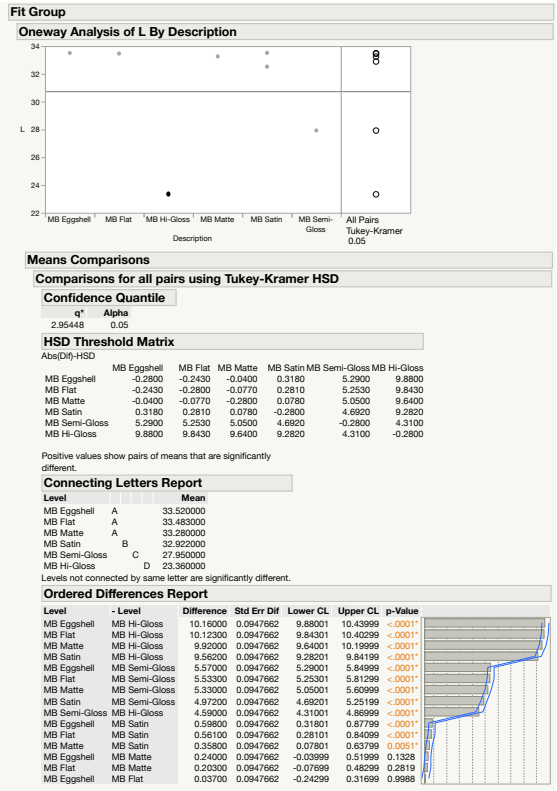
Table 2. Color Measurement Averages by Device

	Midnight Blue Flat			***Midnight Blue Matte***			***Midnight Blue Eggshell***		
	L*	***a****	***b****	***L****	***a****	***b****	***L****	***a****	***b****
X-Rite SP60 SPEX	33.48	-2.63	-6.94	33.28	-2.57	-6.79	33.52	-2.44	-7.00
X-Rite SP60 SPIN	34.85	-2.50	-6.68	34.71	-2.43	-6.51	35.74	-2.25	-6.55
X-Rite 500	34.80	-2.50	-6.42	34.31	-2.50	-6.36	31.26	-2.79	-7.38
	Midnight Blue Satin			***Midnight Blue Semi-Gloss***			***Midnight Blue Hi-Gloss***		
	L*	***a****	***b****	***L****	***a****	***b****	***L****	***a****	***b****
X-Rite SP60 SPEX	32.92	-2.93	-7.41	27.95	-3.42	-8.71	23.36	-3.92	-9.99
X-Rite SP60 SPIN	35.92	-2.56	-6.63	36.05	-2.47	-6.54	35.05	-2.31	-6.48
X-Rite 500	29.12	-3.54	-8.08	26.75	-3.78	-8.83	25.22	-3.68	-9.02

	Whiskers Flat			**Whiskers Eggshell**			**Whiskers Satin**			**Whiskers Semi-Gloss**		
	L*	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***	**L***	**a***	**b***
X-Rite SP60 SPEX	81.63	0.52	81.59	81.59	0.54	5.40	81.14	0.47	5.50	80.35	0.41	5.47
X-Rite SP60 SPIN	81.90	0.52	82.00	82.00	0.55	5.35	81.89	0.48	5.42	81.88	0.41	5.30
X-Rite 500	82.35	0.62	82.00	82.00	0.74	5.88	81.47	0.69	6.06	81.13	0.62	6.04

read (figure 5). They include: Midnight Blue eggshell, flat, and matte sheens using the specular excluded setting and the Whiskers flat, satin, and semi-gloss sheen levels using the specular included setting.

Figure 5. X-Rite SP60 SPEX Mean Comparisons of Midnight Blue using Tukey-Kramer HSD



Fit Group

Oneway Analysis of L By Description

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Confidence Quantile

q*	Alpha
2.95448	0.05

HSD Threshold Matrix

Abs(Dif)-HSD

	MB Eggshell	MB Flat	MB Matte	MB Satin	MB Semi-Gloss	MB Hi-Gloss
MB Eggshell	-0.2800	-0.2430	-0.0400	0.3180	5.2900	9.8800
MB Flat	-0.2430	-0.2800	-0.0770	0.2810	5.2530	9.8430
MB Matte	-0.0400	-0.0770	-0.2800	0.0780	5.0500	9.6400
MB Satin	0.3180	0.2810	0.0780	-0.2800	4.6920	9.2820
MB Semi-Gloss	5.2900	5.2530	5.0500	4.6920	-0.2800	4.3100
MB Hi-Gloss	9.8800	9.8430	9.6400	9.2820	4.3100	-0.2800

Positive values show pairs of means that are significantly different.

Connecting Letters Report

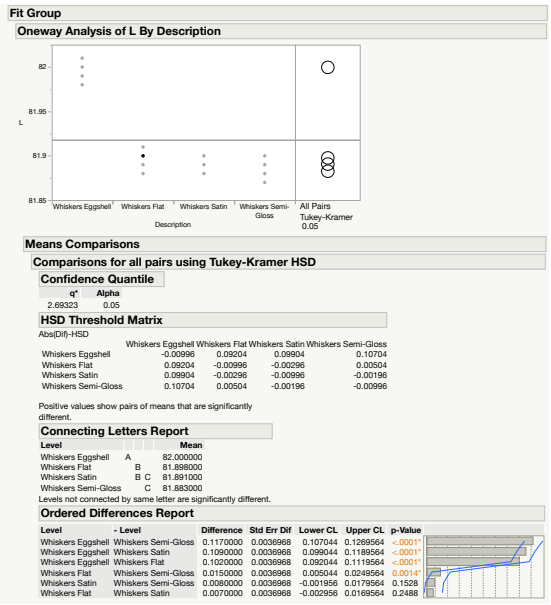
Level		Mean
MB Eggshell	A	33.520000
MB Flat	A	33.483000
MB Matte	A	33.280000
MB Satin	B	32.922000
MB Semi-Gloss	C	27.950000
MB Hi-Gloss	D	23.360000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
MB Eggshell	MB Hi-Gloss	10.16000	0.0947662	9.88001	10.43999	<.0001*
MB Flat	MB Hi-Gloss	10.12300	0.0947662	9.84301	10.40299	<.0001*
MB Matte	MB Hi-Gloss	9.92000	0.0947662	9.64001	10.19999	<.0001*
MB Satin	MB Hi-Gloss	9.56200	0.0947662	9.28201	9.84199	<.0001*
MB Eggshell	MB Semi-Gloss	5.57000	0.0947662	5.29001	5.84999	<.0001*
MB Flat	MB Semi-Gloss	5.53300	0.0947662	5.25301	5.81299	<.0001*
MB Matte	MB Semi-Gloss	5.33000	0.0947662	5.05001	5.60999	<.0001*
MB Satin	MB Semi-Gloss	4.97200	0.0947662	4.69201	5.25199	<.0001*
MB Semi-Gloss	MB Hi-Gloss	4.59000	0.0947662	4.31001	4.86999	<.0001*
MB Eggshell	MB Satin	0.59800	0.0947662	0.31801	0.87799	<.0001*
MB Flat	MB Satin	0.56100	0.0947662	0.28101	0.84099	<.0001*
MB Matte	MB Satin	0.35800	0.0947662	0.07801	0.63799	0.0051*
MB Eggshell	MB Matte	0.24000	0.0947662	-0.03999	0.51999	0.1328
MB Flat	MB Matte	0.20300	0.0947662	-0.07699	0.48299	0.2819
MB Eggshell	MB Flat	0.03700	0.0947662	-0.24299	0.31699	0.9988

X-Rite SP60 SPIN Mean Comparisons of Whiskers using Tukey-Kramer HSD



Fit Group

Oneway Analysis of L By Description

Means Comparisons

Comparisons for all pairs using Tukey-Kramer HSD

Confidence Quantile

q*	Alpha
2.69323	0.05

HSD Threshold Matrix

Abs(Dif)-HSD

	Whiskers Eggshell	Whiskers Flat	Whiskers Satin	Whiskers Semi-Gloss
Whiskers Eggshell	-0.00996	0.09204	0.09904	0.10704
Whiskers Flat	0.09204	-0.00996	-0.00296	0.00504
Whiskers Satin	0.09904	-0.00296	-0.00996	-0.00196
Whiskers Semi-Gloss	0.10704	0.00504	-0.00196	-0.00996

Positive values show pairs of means that are significantly different.

Connecting Letters Report

Level		Mean
Whiskers Eggshell	A	82.000000
Whiskers Flat	B	81.898000
Whiskers Satin	B C	81.891000
Whiskers Semi-Gloss	C	81.883000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Whiskers Eggshell	Whiskers Semi-Gloss	0.1170000	0.0036968	0.107044	0.1269564	<.0001*
Whiskers Eggshell	Whiskers Satin	0.1090000	0.0036968	0.099044	0.1189564	<.0001*
Whiskers Eggshell	Whiskers Flat	0.1020000	0.0036968	0.092044	0.1119564	<.0001*
Whiskers Flat	Whiskers Semi-Gloss	0.0150000	0.0036968	0.005044	0.0249564	0.0014*
Whiskers Satin	Whiskers Semi-Gloss	0.0080000	0.0036968	-0.001956	0.0179564	0.1528
Whiskers Flat	Whiskers Satin	0.0070000	0.0036968	-0.002956	0.0169564	0.2488

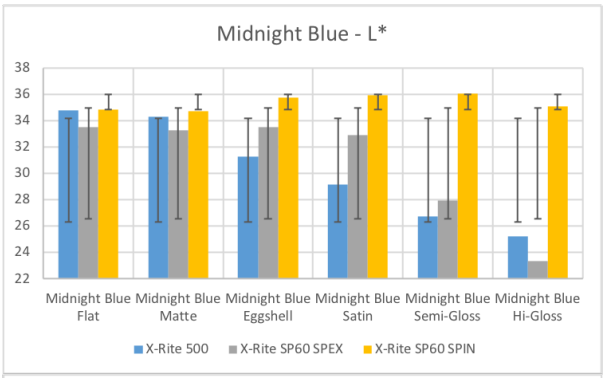
The mean a* readings for all Midnight Blue and Whiskers sheens, the X-Rite SP60 SPEX and SPIN showed significant differences at α=0.05. Surprisingly, the mean a* values read by the X-Rite 500 for the Midnight Blue matte and flat sheens; as well as Whiskers flat and semi-gloss sheens were statistically insignificant, with a p-Value above 0.05.

The mean b* readings for the color Midnight Blue among all sheens showed the X-Rite SP60 (specular included) had statistically insignificant values for eggshell and semi-gloss sheens with a p-Value above .05. All other readings showed significant differences at α=0.05.

It is not surprising that high gloss did not read α>0.05 on any device. The high spectral reflectivity showed significant differences across the board.

When evaluating the mean L* values, the X-Rite 500 and X-Rite SP60 SPEX values decrease as the gloss level increases (figure 6). H1 is confirmed. As gloss level increases, mean L* values will increase in SPIN measurement geometry. The X-Rite SP60 SPIN values remain relatively consistent as evidenced by Tukey HSD. H2 is confirmed. As gloss level increases, mean L* values will remain consistent.

Figure 6. L* values by device



Midnight Blue a* (figure 7) values show an increase as sheen level rises for all devices, with the exception of the Flat and Matte sheens read by the X-Rite 500. Whiskers also shows an increase in a* values for all devices with the exception of the Flat and Semi-Gloss sheens read by the X-Rite 500.

Midnight Blue b* (figure 8) values show an increase as sheen level rises for all devices, with the exception of the eggshell and Semi-Gloss sheens read by the X-Rite SP60 SPIN. Whiskers shows an increase in b* values for all devices. H3 is rejected. As gloss level increases, both instruments will have similar mean a* and b* values.

The line graph in Figure 9 shows the Delta E that was calculated from mean readings using the Delta E 2000 formula. This gives a snapshot of the overall difference between sheen levels by color. The mean flat value from each color was used as the reference for the formula. Overall, Whiskers shows very little difference in value as the sheen level increases for both devices. In contrast, the Midnight Blue shows a more dramatic change in value as the sheen level increases with the X-Rite 500 and X-Rite SP60 SPEX. Not surprising, the X-Rite SP60 SPIN maintains consistent values regardless of color. Interestingly, all instrument's Delta E 2000 values were less than 1.0 for the lighter Whiskers color.

Figure 7. a* values by device

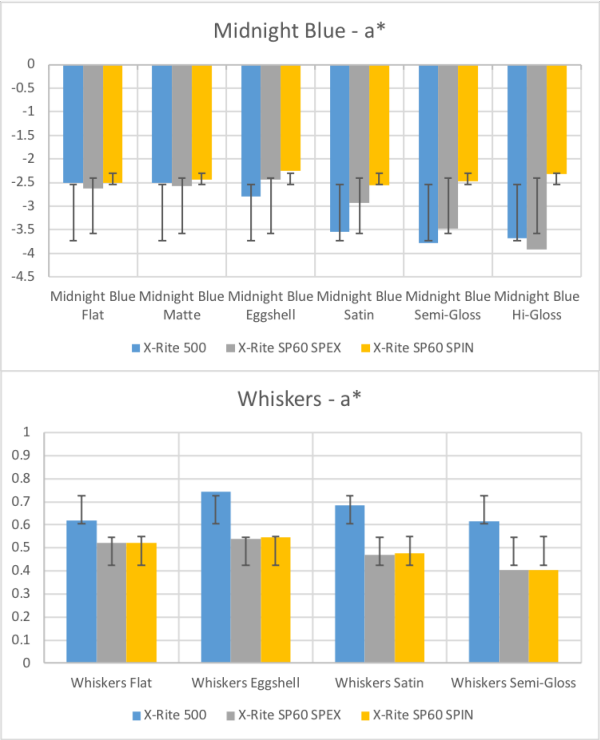


Figure 8. b* values by device

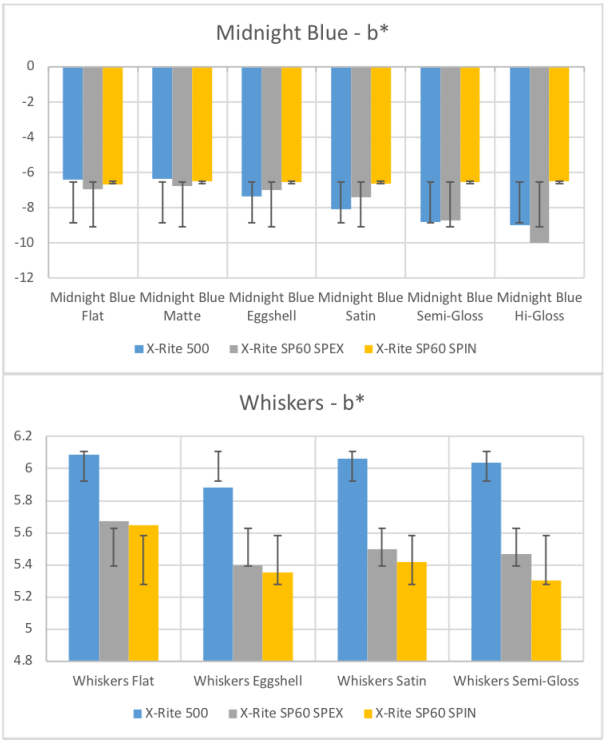
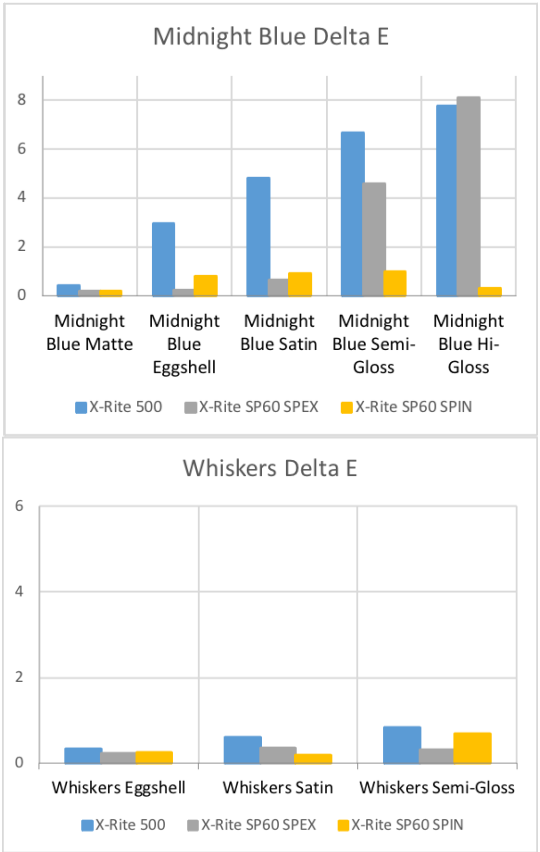


Figure 9. Delta E values by device



Discussion and Conclusions

The purpose of this research is to determine if varying gloss levels affect color measurement.

- H1 confirmed. As gloss level increases, mean L* values will increase in SPIN measurement geometry.
- H2 confirmed. As gloss level increases, mean L* values will remain consistent.
- H3 rejected. As gloss level increases, both instruments will have similar mean a* and b* values.

Various conclusions may be drawn from these findings. First, there is a significant difference in the color values read as the sheen increases. This supports the findings that "As a thicker layer of gloss varnish is added, the color gamut of the gloss vanish continues to exceed that of the uncoated at lower lightness values" (Childers, 2008). This difference is more apparent in the darker color swatch than the lighter color swatch. The difference in readings is important when trying to match brand colors across products with varying varnishes applied. Printers not only have to consider the difference in substrate, but also the difference the gloss creates in how it will affect color matching across products.

It is no surprise that the X-Rite SP60 sphere spectrophotometer using the SPIN reading had measurements closest to the visual assessment of gloss samples. A sphere spectrophotometer uses diffused illumination plus specular pickup and is best used with metallic substrates; hence the specular reflection was not as pronounced. The SPEX reading provided a result closer to the X-Rite 500 that uses the 45°/0° geometry because this device is only capable of specular excluded readings.

The difference color played in Delta E 2000 values supports the notion that when measured in a 45˚/0˚ geometry, materials exhibiting similar surface reflection will have a visual gloss that is higher for darker surfaces (Leloup, 2014, p. 561).

We have determined that gloss levels on printed material affect color measurement. Care should be used when printing with UV and decorative varnishes to ensure accurate reproduction of brand colors. Brand owners should be aware that the use of decorative varnish may alter the consistency of brand color when used across a variety of substrates. Print specialists should communicate to brand owners regarding this variation in color consistency when decorative varnishes are applied.

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Exploring the Programmatic Impact of Industry Expert Adjuncts in Two Graphics Departments

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Abstract

Adjunct faculty are part-time or contingent full-time faculty who are ineligible for tenure and exist outside of the tenure-track system. Emerging from their increased use by higher education over the past fifty years (Donoghue, 2008), there are a variety of narratives attached to the adjunct experience. One such tale describes the plight of the adjunct who is teaching several courses, perhaps at different institutions, desperately trying to cobble together the semblance of full-time employment. Stories like this one highlight the different lived experiences of adjunct teaching faculty and their tenured and tenure-track colleagues.

Although adjunct faculty are not always in teaching roles, this work focuses on adjunct teaching faculty, without the inclusion of those in contingent research faculty positions. We have defined a category of adjunct faculty, the Industry Expert Adjunct (IEA), as instructional part-time teaching faculty whose primary, full-time employment is outside of academia (Walker & Boyer, 2020). Other fields, such as Nursing and Business, use positions such as "clinical teaching faculty" or "professor of practice" in much the same way as Industry Expert Adjunct, however, with IEAs, there is a clear distinction that the adjunct position is part-time and teaching is not the IEA's primary employment.

The IEA model is different from other forms of adjunct teaching roles as it is based on the instructor's current, authentic industry knowledge and the opportunity to convey that knowledge to students in the classroom. IEAs are the primary course instructor, rather than co-teaching or guest presenting, providing students with a semester-long experience through which they can interact with an experienced and knowledgeable expert from industry. In this paper, we share the broader context for adjuncts in current literature and synthesize results from the authors' previous research with evidence from current practice towards a better understanding of the programmatic impact of IEAs.

Keywords: Full time faculty, Adjunct faculty, Hiring, Industry expert adjunct

Introduction

Harrowing narratives describe the lived experiences of non-tenure track adjuncts and are reinforced by the evidence documenting the institutional status, work context, and professional lives of adjunct faculty. In 2008, 65% of faculty were in the category of adjunct faculty, defined as those ineligible for tenure, with 85% of those individuals on contracts of one year or less (Donoghue, 2008). Current reporting has the number of adjuncts ranging from 70% (American Association of University Professors, 2021) to 75.5% of college faculty (New Faculty Majority, 2021). Similar reports recount significant negative impacts of being part-time or contingent faculty including lower pay and lack of access to retirement and health care benefits, as well as increased stress, uncertainty, and burnout (e.g. American Federation of Teachers, 2020; Flaherty, 2020a, 2020b).

Research on adjuncts includes examination of how differences in the lived experiences of adjunct faculty impact student learning, often contextualized in negative terms. The report An Army of Temps (American Federation of Teachers, 2020) frames the argument:

Students are not receiving the best possible education when the instructor in front of them is struggling to decide whether to buy food or medicine, and students' futures are jeopardized when an inspiring professor who could provide a recommendation or further mentorship is let go as soon as the academic term ends.

In their book The Gig Academy (Kezar, DePaola, & Scott, 2019), the authors provide an overview of findings from work focused on student impact:

Research into the growth in contingent faculty has documented some negative outcomes for students related to transition, retention, persistence, graduation, transfer, and academic performance, particularly among first-generation, low-income, and racially minoritized students.

From a deficit-only perspective, these trends are certainly alarming, however, this paper presents evidence from a particular type of adjunct teaching faculty experience telling a different story about this segment of adjunct teaching faculty, the IEA.

Comparative Cases

The cases used in this work are two graphics departments that hire IEAs as instructors. One is a department in the School of Art and Architecture in the northeastern United States in a unionized state school and the other is a department in the College of Business in the southeastern United States in a "right to work" state. Both degree programs reside in public research universities with an undergraduate student population of approximately twenty thousand students. The first program will be identified as Program One and the second program will be called Program Two in the following comparative study.

This paper uses these two cases to explore areas of conceptual and operational similarities and differences. Given that the programs are from differing contexts, this paper does not intend to evaluate each case considering the other but rather synthesize qualitative results from data collection and analysis into similarities and differences that are theoretically informative and practically actionable themes for further research and development.

Description of departments and the IEAs

Program One serves about three hundred undergraduate students and ten graduate students. The undergraduate program confers Bachelor of Fine Arts (BFA) degrees and the graduate program awards Master of Fine Arts (MFA) degrees. The department currently has eight full-time faculty members who are either tenured, tenure-track, or non-tenure track and between twenty and thirty IEAs, depending on instructional needs.

Program Two has approximately three hundred and fifty undergraduate students and ten graduate students. Undergraduates receive Bachelor of Science (BS) degrees and graduate students earn Master of Science (MS) degrees upon graduation. The faculty includes nine tenured or tenure-track faculty, five full-time lecturers, and seven IEAs, four of whom teach exclusively in the associated minor.

A large portion of IEAs in Program One are alumni of the program. To diversify IEA hires, the department also recruits IEAs outside of the alumni network through faculty members' industry connections. Occasionally, people reach out directly and express an interest in teaching, often from companies that frequently hire program graduates.

A few of the current IEAs in Program Two are alumni of the undergraduate or graduate program. Others

work in full-time positions at the University, within their area of expertise, but studied elsewhere. Additional IEAs have been recruited from local businesses that are closely tied with the department and regularly hire graduates and interns.

When considering what motivates an IEA to teach a course, previous research includes a nationwide survey of IEAs teaching in creative fields. Forty-four IEAs from across twenty programs responded to the survey. This broader study showed that a primary reason that IEAs teach courses is for the opportunity to connect with students. 100% of IEAs stated that they enjoyed mentoring, 68% liked the prestige of teaching, and found fulfillment in being a part of the department (Walker, Guido, & Boyer, 2021).

While some IEAs are motivated to teach a course to earn supplemental income in the context of the two departments featured in this study, the pay per credit hour currently ranges from $1550 to $2500. The pay rate an adjunct receives for teaching a course can vary for many reasons including level of experience, holding advanced degrees, or local oversight by a union that negotiates adjunct pay rates. However, the time required to teach a course is often significantly higher and the pay lower than what an IEA could make doing additional contract work in their field. Therefore, other outside opportunities are often more profitable than teaching.

One advantage to IEA teaching positions in both programs is that the baseline qualifications for a candidate can be more flexible than the requirements for full-time instructors. This encourages a more diverse and experienced applicant pool. In many universities, academic credentials are necessary to maintain accreditation and other established benchmarks, but exceptions can be made to capitalize on the unique expertise of those with established careers when hiring IEA instructors. For example, in Program One the hiring committee found that holding an advanced degree is not the traditional path for working professionals and many IEA candidates continued into industry after earning their bachelor's degree rather than pursuing a terminal degree. Of those who have a master's degree, they often pursued it to facilitate a career change or because they desire to eventually teach full time. Therefore, IEA part-time teaching positions rarely attract applicants holding terminal degrees.

Traditionally, adjunct instructors at both universities in this study have a terminal degree in their field of expertise, but significant industry experience can supplement that requirement when applying for an IEA position. The flexibility of accepting experience as a qualification helps broaden the potential candidates when recruiting new IEAs which also makes a positive impact on the diversity of instructors and of courses offered in each program. When exceptions are not possible within the structure of the program or university, Program Two lists a full time faculty, who is also the faculty liaison for the IEA, as the instructor of record on the course.

Onboarding, training, & support

When a new IEA is hired in Program One, they begin the onboarding process at the university level. Often the official hiring process does not conclude until very close to the start of the semester, but the new faculty member is able to gain access to internal systems while still completing the necessary paperwork to become an official employee. Both the department and college run workshops for all newly hired IEAs either annually or semi-annually. The larger, collegewide meeting discusses teaching logistics and strategies. The department-level meeting provides updates to the entire faculty regarding changes to the curriculum, procedural updates, and hands-on-training for Canvas, the Learning Management System. The university also has a Center for the Advancement of Teaching which provides optional training in Canvas and other helpful teaching resources throughout the academic year to all instructors including IEAs.

Newly hired full-time employees in the Program Two department go through an onboarding process at the university, college, and departmental level. However, IEAs are not always included in these meetings. When the appropriate paperwork is filed with Human Resources to establish payroll, new IEAs gain access to email, Canvas, university-provided software programs, and other necessary tools automatically but part-time instructors rarely receive invitations to other onboarding activities such as training and logistics. Instead, course training and administrative help is handled by a faculty liaison who is assigned by the department to assist the new IEA. Currently, there is no oversight or standard process for the faculty liaisons, so the training and assistance varies. Some administrative assistance is provided by the department chair and staff, but the majority of classroom and educational support is handled by the faculty liaison and tailored specifically to the needs of that instructor and course.

In Program One there is a department chair, program head, and scheduler who play a role in providing support to IEAs while also balancing their own teaching load. As a team, they streamline the hiring process, provide help with course design, and set up courses in Canvas for the IEAs each semester. Help with the curriculum varies based on the demands of the course material and the modality but the availability of this support is consistent across all IEAs working in the department.

Over 80% of IEAs in Program One teach elective courses that align with the industry where they work. The courses are customized by the IEA to address the topics that are most timely and relevant in their field. A handful of IEAs teach required classes which have a course coordinator that is a full-time faculty member. In those cases, the course coordinator is responsible for designing the course syllabus and administrative support such as setting up the course shell in Canvas.

All IEAs in Program Two teach elective courses, so less faculty-wide oversight is provided in the development of course materials. However, the IEAs who teach in the associated minor program have access to a full-time program coordinator who assists with course development and administrative logistics. Like the Program One department, the courses taught by IEAs in Program Two are shaped by their personal, work experience. IEAs develop or co-develop assignments, projects, lectures, and assessments reflecting their industry best practices and systems. As a result, the title and course description are agreed upon by the full faculty, but specific materials within the course are instructor-driven. The faculty liaison or the program coordinator works with each IEA individually to ensure that the syllabus and course materials meet departmental standards.

Advantages to hiring IEAs

There are many benefits to having IEAs as an essential part of the overall curriculum in both departments. The IEAs ongoing connection to industry and their need to stay current in both technology and trends helps keep the overall department curriculum up to date. Students benefit from exposure to the IEAs' professional network, organizations, and resources. Many IEAs are leaders in their industry and/or run their own businesses, providing students with a diversity of workplace perspectives.

Timeliness through daily exposure to industry

While full-time faculty and the IEAs in both departments have some overlapping areas of expertise, full-time faculty do not have the added benefit of also working in the industry day-to-day (Walker, & Boyer, 2020). For example, Program Two has a required course in film production taught by a full-time faculty member who used to work in the industry. By adding an IEA with this area of expertise to the faculty, there is now an advanced filmmaking course taught by someone who creates video content every day at their full-time job. While both instructors bring valuable experience and knowledge to the classroom, the IEA has the advantage of living in both worlds. This provides students with timely exposure to current industry trends that a full-time faculty member is less likely to be able to provide.

Students gain opportunities for networking

Another advantage is that students gain access to positions after they graduate, either with the IEAs company or through the IEAs professional network. While the Program One department has a rule that IEAs cannot hire students as interns while they are enrolled in their class, they can and often do hire students after they have completed their class(es). Many IEAs in the Program Two department bring their colleagues into the classroom through guest lectures and by including them in end-of-term events such as portfolio reviews, mock- interviews, and as feedback panels during final presentations. These classroom events introduce students to additional industry experts and provide broader feedback on student work which better prepares them for internship and job interviews.

Expansion of course offerings

IEA-taught courses expand course offerings beyond what can be offered by the full-time faculty alone, both from a course load and content knowledge perspective. In this way, IEAs fill in gaps of knowledge in the full-time faculty body. For example, the Program One department has a course in typeface design that is being taught by an IEA who creates typefaces full time. While some of the other faculty have explored typeface design, none of the full-time faculty has expertise in this field. Having IEAs helps expand course offerings based on including instructors with these additional areas of expertise. Another example in the Program Two department is a two-course series in web design and development. The full-time faculty member teaches an introduction to web coding and an IEA teaches a follow-up course that drills down into User Experience (UX), a field that the faculty member understands but the IEA works in full time. UX and web

development is a rapidly changing field so the IEA-taught course provides insights that keep the curriculum timely and in line with current industry standards.

Challenges and strategies for hiring, supporting, and maintaining IEAs

Although IEAs provide great benefit to departments and to the students, there are challenges to recruiting, training, and maintaining these types of instructors. IEAs have a wealth of timely industry experience but they can face difficulties translating those ideas into a classroom setting. They need to understand basic pedagogy and classroom maintenance to effectively share their knowledge with students. Addressing this gap requires the attention of administrative staff and faculty support which can drain already stretched departmental resources. This additional time investment becomes more frustrating when IEAs decide to no longer teach due to changes in their full-time career or families.

The academic calendar and the associated pacing inherent in academia is much different than IEAs experience in industry. This also presents challenges. Planning and hiring for courses happens months in advance and official changes to curriculum can take years to go into effect. Integrating IEAs into the faculty team is difficult since many university meetings and events occur during regular business hours and IEAs are unable to fully participate in the same way that full-time faculty can. Finally, balancing the demands of a full-time career with student expectations for availability can cause frustration for both parties. Each of these challenges and the corresponding solutions used by these programs are addressed in more detail below.

Supporting pedagogical and classroom training for IEAs

One obstacle when IEAs move between industry and the classroom is that their primary focus is on their craft and they do not have much knowledge about teaching. Understandably, they invest much less time staying up to date on pedagogy and classroom best practices than full-time faculty do which can create challenges in the classroom. In the worst-case scenarios, IEAs become frustrated about student work ethic and their investment in the course material. Because IEAs decision to teach a course is often focused on interacting with students, this frustration has caused some IEAs to stop teaching. On the other hand, most IEAs are very open to hearing feedback on their teaching methods and curriculum and many express an interest in learning more about how to improve their courses. This is where it is important for administrators and faculty liaisons to provide professional development opportunities and other teaching support in a way that is useful and functional for a part-time instructor. Support can come from many sources including from the department level or the university Teaching and Learning Center, but it must be appropriate and tailored to address the needs and time constraints of the IEA instructor.

Departments need to consider additional administrative and teaching support staff and faculty to support IEAs

Since IEAs are teaching part time, reducing the administrative requirements placed on these instructors increases the time they have available to spend with their students and in course improvement. Simple tasks like ensuring room access, explaining parking options, setting up courses in Canvas, or submitting final grades can be handled for the IEA by full-time employees. While managing these tasks does not take a lot of time for a course or two, as the number of IEA-taught courses increases, the time it takes to perform these support tasks necessitates additional staffing.

Addressing competing interests since this is not their only job

Some challenges, like turnover and balancing the demands of two jobs, are innate to the IEA model. The difficulties of investing in temporary employees should be acknowledged. Since IEAs do maintain full-time careers while teaching their course, it can be challenging to find an IEA who can continuously commit to teaching every semester. Both programs have IEAs who have taught continuously for many years, but most IEAs need to take occasional breaks from teaching to address other priorities such as family planning. When an IEA becomes a parent, they might find balancing a full-time job, a family, and a teaching position to be overwhelming. In other cases, IEAs might accept a promotion or move away for new job opportunities and can no longer commute to campus to teach. Some IEAs simply burn out from balancing too many obligations, deciding that being an IEA is not worth the perceived benefits.

When an IEA who teaches an established course leaves their teaching position, departmental adjustments need to be made

Sometimes an IEA in a similar career can be hired to step in and teach a course that is already established, but it is anticipated that their course

will be individualized to a large extent in order to reflect their personal experience in industry. Other times that course must be put on hold until a suitable instructor can be hired. This is especially difficult when it happens close to the beginning of a semester and students have already enrolled in the course.

In both departments featured in this comparative study, most courses are lab-based courses and include significant studio time

This means that each course needs to meet for 5-8 hours each week. Scheduling that many hours away from work can be difficult. Some IEAs only teach in the evening, others negotiate with their employers for flex hours to teach in the late afternoon, and others are sole proprietors and therefore able to build a work schedule around their course times. No matter when they teach their class, IEAs often need to come on campus to teach more than one day a week to fulfill the contact hour requirement for studio-based courses. Anecdotally, both programs have seen better retention rates with IEA instructors who are able to teach their courses in a single day each week.

Another challenge faced by both IEAs and their students concerns their availability outside of class time

Students often anticipate access to their instructors through email or video conferencing during non-class hours. Full-time faculty address this need by hosting office hours and open lab times, but IEAs need to focus on their other obligations when they are not teaching. This can create frustration when students choose to work on assignments during outside hours. One effective solution is to clearly state availability and expected response times in the syllabus and verbally on the first day of class.

Scheduling IEA courses can be difficult because of the long timeline academia requires for posting courses prior to student registration

Some institutions schedule courses before confirming an IEA instructor, but that can lead to cancelled courses with students already enrolled. For example, in Program One, course schedules are in place by November for the following fall semester and by July for the following spring semester. It can be challenging for IEAs to commit to teaching a course nine months in advance. An unpredicted change of their full-time position or new demands in their family life might leave them unable to fulfill their teaching commitments. When this happens, the department tries to replace the instructor with someone who has the same area of expertise and can teach during the pre-scheduled class time.

Since many IEAs teach in the evening, they do not have regular contact with full-time faculty members or the department administration. This can cause IEAs to feel isolated and not a valuable member of the faculty. Program Two has found that there needs to be a balance when including IEAs. If they receive too many departmental emails or feel obligated to attend all the department events, they may feel overwhelmed with the additional expectations. This is a challenge that demands a creative cultural solution.

In the Program One department, building a community in the department has been a priority. Ways to address this challenge include a yearly all-department meeting with a full meal, a semi-annual IEA meeting to promote community within the adjunct instructors, inclusion in the faculty Slack channel, and creating an annual award for excellence in the classroom demonstrated by an IEA instructor. While there is no monetary award, the simple acknowledgement has elevated the feeling of inclusion within the department. By inviting IEAs to important departmental and college-level events throughout the year such as portfolio reviews, final presentations, and alumni happy hour, camaraderie is built between full-time and part-time faculty and IEAs actively see the importance of their role in the overall departmental goals.

Conclusions

Integrating IEAs into the curriculum can provide enormous value to both faculty and students. Hiring an IEA costs less than hiring a full-time instructor and IEAs bring current industry knowledge into the classroom, providing opportunities for students to connect theory with practice and network with professionals on a deep level.

Expanding a graphics program by hiring IEA instructors can start small with just one or two IEA hires. The administrative burden of adding a few IEA-taught courses can often be managed by a current faculty member acting as a liaison to help with pedagogy as well as the necessary logistics. However, if a department wants to expand to a larger number of IEA-taught courses, the additional resources necessary for pedagogical training, guidance in classroom management skills, and general administrative help needs to be considered. It should be noted that neither of the programs represented in this case study experienced excessive difficulty with union

regulations, contracts, or required credentialing but it is recognized that each program may face requirements and red tape that differ in their own setting.

The comparative cases in this work are two different graphics programs that include IEAs as an important part of their faculty. In both departments, the benefit of IEA-taught courses outweighs the effort required to hire, train, and support IEAs. Common challenges and strategies for addressing them are shared with the hope that these experiences might benefit other programs interested in working with IEA instructors.

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Measuring the visual learning capacity of people over 60 years old: A comparison study between static and animated infographics

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Abstract

The utilization of static and animated infographics to convey information is a common occurrence in business, industry, and education. What is of interest to many in the field is the impact that each of these methods may have on improving level of comfort in executing various tasks, especially with those that may not be technologically savvy. This research examines the impact on improving comfort level for participants of a certain age between static and animated infographics.

Keywords: Learning improvement, animation, static graphics, comfort level, infographics

Introduction

Infographics are data visualizations that present complex information quickly and clearly. Data visualization includes signs, photos, maps, graphics, and charts to present complex data visually. The infographic is part of data visualization. Infographics are composed of three major components: Visual elements, Content elements, and Knowledge:

- Visual elements–colors, graphics, signs, icons, maps, etc.
- Content elements–facts, statistics, texts, references, time frames, etc.
- Knowledge–conclusion to express the stories or messages (Thatcher 2012).

Infographics are the tools that the media uses to provide a large amount of information to the audience in a simple, understandable way. Infographics present data in the shortest possible time with high visual appeal.

Since the beginning of recorded time, humans have been using pictures to communicate with each other. Sumerians used pictographs for record-keeping purposes, and Egyptians used hieroglyphics to capture their history (Davis & Quinn, 2014). Infographics are modern, written artifacts about collected resources presented in a dynamic, visual format. This concept stems from information literacy, the "set of skills needed to find, retrieve, analyze, and use information" (Davis & Quinn, 2014). Due to time limitations and the vast volume of data, the value of using this graphic format is becoming more and more apparent (NuhogluKibar & Akkoyunlu, 2017).

Literature Review

The value and usage of infographics

When transferring, finding, or explaining content to the audience, the verbal explanation is simple and effective but might be a little boring to the listener. Therefore, people might not memorize all or most of the content (Salimi & Mazlumifar, 2013). The human mind understands visual data faster than textual data. Usually, visual language is more effective than any other communication method to disseminate knowledge (Salimi & Mazlumifar, 2013). Humans are visual creatures, and half of the brain is dedicated to vision. In addition, 65% of people are learners whose visual attendance provides information attention? (Salimi & Mazlumifar, 2013). When images are processed in the brain, humans receive information 60,000 times faster than text. As a result, the use of this type of method for training simplifies the learning process. Visuals can also play a significant role in remembering and retrieving data. Visual language allows humans to both experience and document experiences in a visible way (Salimi & Mazlumifar, 1392).

Infographics or informational graphics as a tool for visualization and visual display of data and information can significantly contribute to the spread of knowledge. Infographics are created to increase the rapid sharing of complex ideas in graphic formats (Lamb & Johnson, 2014). Infographics are popular tools for sharing institutional and research data with audiences. Many websites offer software to help users create these visual representations of information (Wright, 2016).

The term information visualization is easily associated with thoughts of making graphics and images. However, it truly offers more insights than that alone. Information visualization is a cognitive process used for analysis and presentation, allowing us to understand data better and offering the opportunity to act upon the understanding it provides. It also enables effective communication and representation, further solidifying that the purpose of visualization is to gain insights, not simply to view pictures (Chen, 2017).

An infographic is the "visualization of data or ideas that tries to convey complex information to an audience in a manner that can be quickly consumed and easily understood" (Smiciklas, 2012). Infographics allow for quicker and more effective communication than spoken or written formats (Siricharoen, 2013). Infographics enable learners to visualize the big picture of a complex idea or content and helps teachers effectively represent this complex overview to students (Lamb & Johnson, 2014; Davidson, 2014).

Designing Infographics

The first step to creating an infographic is to gather information and abstract data. The creation of a visual artifact is a process that happens in a sequence of successive stages. These stages are as follows:

1. Preprocessing and data transformations,

2. Visual mapping:

- The spatial substrate defines the dimensions in physical space where the visual representation is created. The spatial substrate can be defined in terms of axes.

- Graphical elements are everything visible that appears in the space. There are four possible types of visual elements: points, lines, surfaces, and volumes.

- Graphical properties are properties of the graphical elements to which the human eye's retina is very sensitive. The most common graphical properties are size, orientation, color, texture, and shape.

3. View creation (Mazza, 2009).

What makes a good infographic?

The most powerful infographics include the following elements:

- Purpose: The audience should be able to infer the author's purpose, draw conclusions based on the evidence, and summarize the gist of the infographic.

- Style: The graphic components, including the layout, text, symbols, and color schemes, should address the author's tone.

- Evidence: Data and text must be cited and appropriately integrated into the design to support the reader's understanding.

- Format: The infographic can be represented in a static format designed for print or a dynamic medium that allows interactivity (Davis & Quinn, 2014).

Animated vs. Static infographics

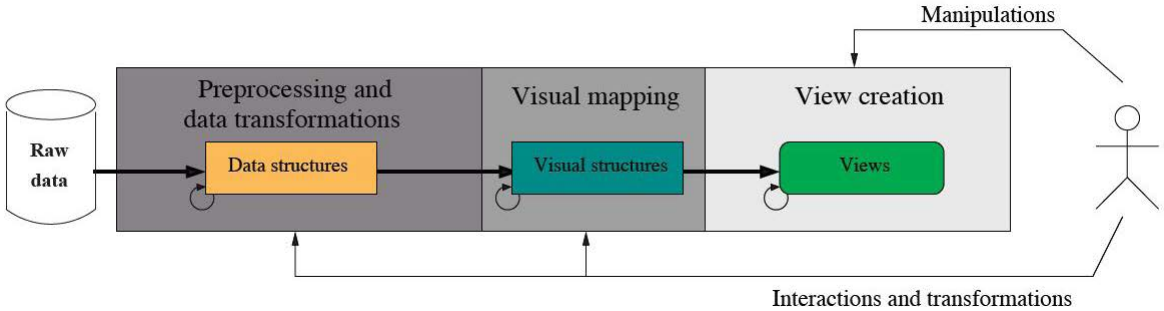
Representation serves as the medium for all forms of communication. Humans often connect thoughts and ideas to an object, which is not even physically present, employing mental representation. There are five approaches to organizing information in a discernible pattern: chronological, alphabetical, geographical, categorical, and hierarchical. Through any of these approaches, data can be communicated very effectively (Yildirim, 2017).

There are several types of infographics, namely interactive, semi-interactive (animated), and non-interactive (static). The classification of these types depends on the multimedia components they contain (Yildirim, 2017). Static infographics contain text and non-animated visual components. And the information contained in this type of infographics is confined to the content provided. In addition, this type of infographic is commonly printed. Animated infographics can contain the same content as in the static type. However, the information is presented through motion or animated scenes rather than viewed as static steps or blocks of information. The animated infographic attracts more viewers through the unique visual animation characteristics. Interactive infographics can provide the same information as in the other types but with multimedia sources and the ability to interact with the content (Lankow, Ritchie & Crooks, 2012). For example, audio files, animations, or animated drawings are common elements in animated and interactive infographics. There are other styles of interactive infographics that users select and access information according to their choices. This feature provides information as a whole or in user-selected bits and satisfies the need for additional information (Afify, 2018).

Teaching older adults

Technology impacts the lives of older adults in ways that were unimaginable 50 years ago. From 2008 to 2018, the population aged 65 and older increased from 38.8 million to 52.4 million (a 35% increase), and this population is projected to reach 94.7 million in 2060 (Administration for Community Living, 2020). Although technology is becoming embedded in society, older adults are adapting to technology at a slower rate compared to younger individuals (LoBuono, Leedahl & Maiocco, 2020). For instance,

Figure 1. The process of generating a graphical representation (Mazza, 2009).



90% of all American adults have used the internet; however, only 73% of older adults report using the internet (Pew Research Center, 2017). Rarely studied online, this population of older computer users is growing in skill level and desire to remain active and challenged by engaging in computer and internet activities. Several quantitative studies conducted with the senior population demonstrate older adults' positive attitudes toward computers, learning abilities and needs, and most frequently used computer applications (Clark, 2002). Together, the amount of knowledge regarding older adults and their abilities, capabilities, and benefits of using a computer and the internet is expanding. As the number of older adults continues to grow, perhaps one of the ways to teach technology, cell phone features, and the internet to older adults is through animated infographics.

Method

Research Purpose

The purpose of this study was to examine whether animated or static infographics improved acquisition of new information for participants over 60 years old. In this research, the authors created one static and one animated infographic targeted at an audience of people who are over 60 years old about how to use a new feature of smartphones. One of two infographics, animated or static, were randomly displayed using an online survey tool. Half of the participants watched the animated content, and the other half of participants saw the static infographic. In total there were 32 participants. Both infographics contained the same information and visual styling.

Before gaining access to the infographic, the participant's knowledge of the topic was tested by filling out a pre-survey. Each group viewed either the static graphic poster infographic or the animated infographic. After viewing the infographics, participants in both conditions filled out a post-survey. This survey included multiple-choice questions about the presented content. The resulting survey data was compared and analyzed using statistical methods.

The analysis was performed in two phases:

Phase 1: To test whether the impact of the static graphic poster infographic is equal to the impact of the animated infographic or not.

Phase 2: If it can be concluded the impacts of each condition are not equal (from phase 1), then the researchers investigated whether the impact of the animated infographic is higher than the impact of the static graphic poster infographic or not.

The researchers obtained independent and identically distributed (IID) samples from two separated populations.

In the next step, the researchers posed questions to evaluate the level of comfort with the associated tasks. These questions were categorized into three areas listed in Table 1.

The questions were designed to indicate knowledge from before and after viewing the static graphic poster or animated infographics. Responses were mapped to numbers for analysis where one showed "extremely uncomfortable," and five dictated "extremely comfortable." 3 represented a neutral response of "neither comfortable nor uncomfortable."

Table 1. Level of comfort questions answered by participants before and after viewing the animated or static graphic poster infographics.

Lock screen PIN or password
Q1: Can you change your cell phone lock screen PIN or Password easily?
Q2: Can you set or change the passcode in your smartphone easily?
The text size of the font
Q3: Can you change the text font size in your smartphone easily?
Q4: Can you change the text font size in your smartphone easily?
Setting up the medical ID
Q5: Can you set up a Medical ID in your smartphone easily?
Q6: Can you set up a Medical ID in your smartphone easily?

Results

Static Graphic Poster

Figures 2, 3 and 4 show results in the change in comfort level indicated for each of the three tasks before and after viewing the static graphic poster infographic.

Figure 2. Static Graphic Poster Changing Cell Phone Lock Screen

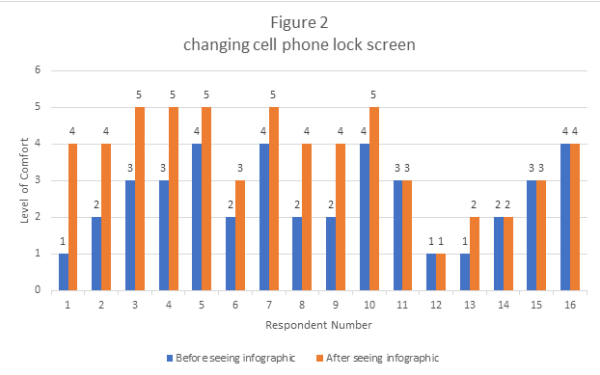


Figure 3. Static Graphic Poster Changing Text Font Size

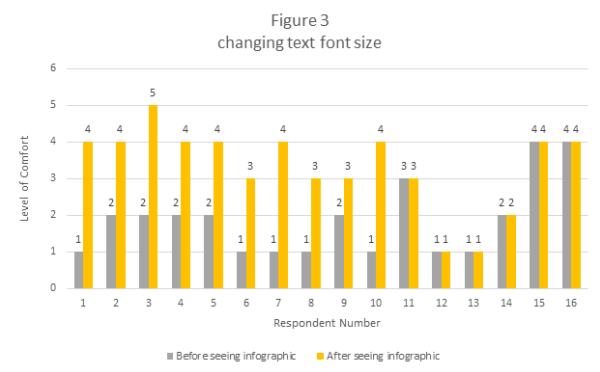
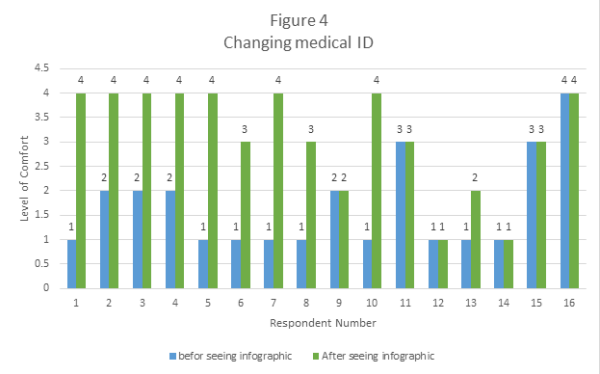


Figure 4. Static Graphic Poster Changing Medical ID



Animated Infographic

Figures 5, 6, and 7 show the change in comfort level indicated for each of the three tasks before and after viewing the animated infographic.

Figure 5. Animated Infographic Changing Cell Phone Lock Screen

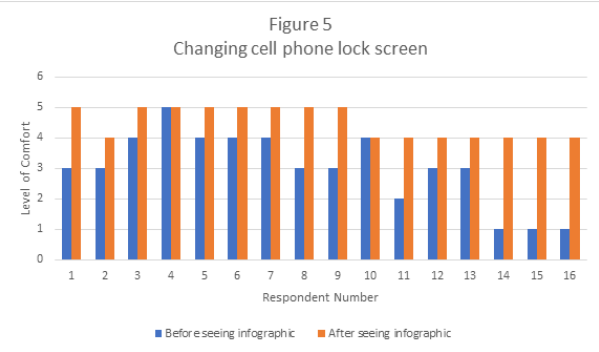


Figure 6. Animated Infographic Changing Text Font Size

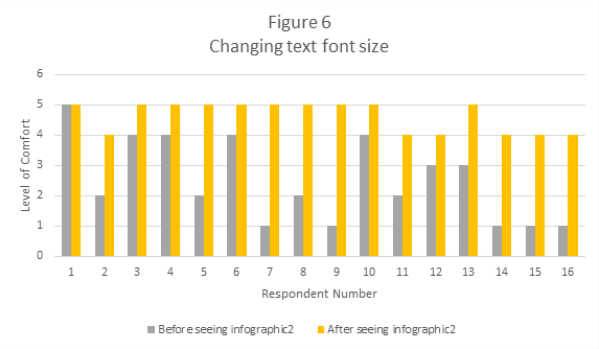
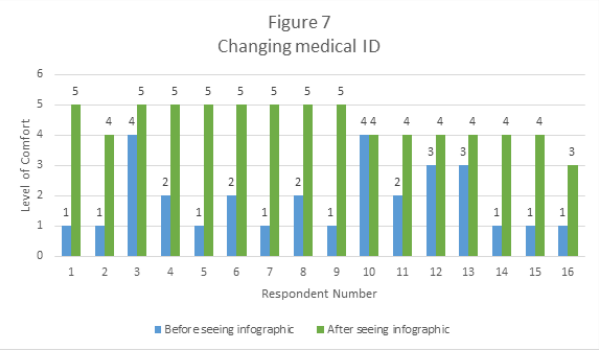


Figure 7. Animated Infographic Changing Medical ID

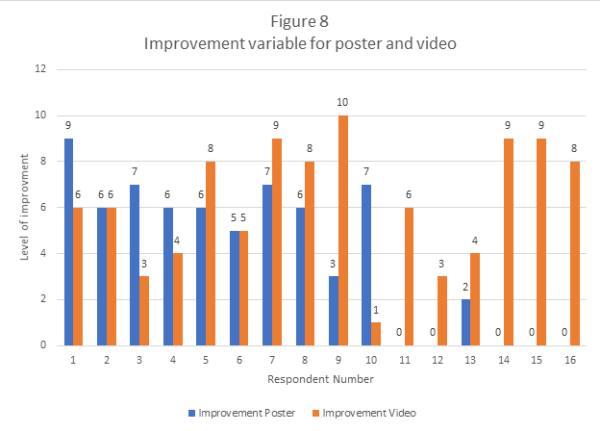


The researchers defined an Index Improvement variable for both static graphic poster and animated infographics as the difference between the sum of the three questions after training and sum of the three questions before training. Improvement Index was calculated as follows:

Improvement Index = (Q6+Q4+Q2) - (Q5+Q3+Q1)

The researchers calculated this Improvement Index for both static graphic poster and animated conditions. The results can be observed in Figure 8.

Figure 8. Improvement Index for Static Graphic Poster and Animated Infographics



The researchers performed a t-test analysis in both phase 1 and phase 2. Assuming that the variances of the two populations are equal (), the results associated with the gathered data and defined variable (improvement) are summarized in Table 2.

Table 2. Statistical results of the two conditions

	Animated	*Static Graphic Poster*
Mean ()	*6.19*	*4.00*
Variance ()	*7.10*	*10.27*
Observations ()	*16.00*	*16.00*
Pooled Variance ()	*8.68*	*8.68*

Pooled variance () was calculated with the following formula

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 + n_2 - 2)}$$

Phase 1:

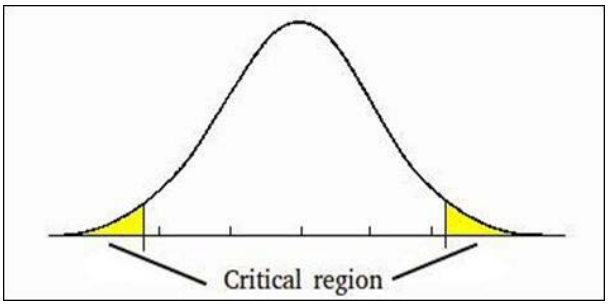
The researchers constructed the following hypothesis:

H_0: No significant difference can be observed between the static graphic poster and animated infographics ($\mu_1=\mu_2$).

H_a: There is a significant difference that can be observed between the static graphic poster and animated infographics ($\mu_1\neq\mu_2$)

A two-sided t-test analysis was conducted to test if there is a significant difference between the two strategies.

Figure 9. Two-sided t-test analysis



Considering, α=0.05 P (T ≤ t) two-tail = 0.044 is smaller than 0.05, it can be concluded that at a 5% significance level, the researchers should reject the null hypothesis. There is enough evidence to support the claim that the impact of animated infographic is not equal to the effect of static graphic poster infographic.

Phase 2:

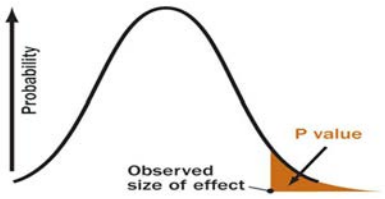
The researchers constructed the following hypothesis:

H_0: The impact of the animated infographic is equal to the static graphic poster infographic ().

H_a: The impact of the animated infographic is more significant than the static graphic poster infographic ().

A one-sided t-test analysis was conducted to test if the improvement between strategies is significant.

Figure 10. One sided t-test analysis



Considering P (T ≤ t) one-tail = 0.0221 is smaller than 0.05; therefore, it can be concluded that at a 5% significance level, the researchers should reject the null hypothesis. There is enough evidence to support the claim that the impact of the animated infographic is significantly more than the impact of static graphic poster infographic.

Conclusion

The researchers compared the impact of both static graphic poster and animated infographics on the improvement of user performance in three main categories: changing lock screen PIN or password, changing text size of the font, and setting up the medical ID.

Through the statistical analysis in Phase 1, the researchers concluded that there is enough evidence to support the claim that the impact of the static graphic poster infographic is not equal to the effects of animated infographic. According to the Phase 2 analysis, there is enough evidence to support the claim that the effect of the animation on learning in this population shows an improvement that is significantly greater than the learning impact of the static graphic poster infographic.

Future research should consider this research was done with a small sample size population. Therefore, results could vary in a larger population. Also using different scientific topics to teach older adults through interactive infographics would be a good subject to research in future studies.

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GRAPHIC COMMUNICATIONS EDUCATION ASSOCIATION

Visual Communications Journal Fall 2021 Volume 57 Number 2