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Curricular Analysis of Graphic Communication Programs

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Abstract

Advances in technology have revolutionized both the graphic communication industry and graphic communication education. However, as graphic communication programs have updated their curriculum over the years, little has been done to document the direction of these programs. The purpose of this study was to examine the United States baccalaureate graphic communication programs to synthesize current curricular requirements. When academic units look to develop or re-design curriculum, it is done with external, institutional, and unit-level forces playing a role. Institutionally, programs identify their fit within the institution's mission, resources, and governance. Externally, programs engage stakeholders such as advisory boards, industry partners, and accrediting agencies. As a unit-level force, faculty are typically key decision-makers in the curriculum development process. Within graphic communication education, faculty are provided with a surplus of studies looking at competencies and skill sets, industry trends, course techniques, and pedagogy. Yet, there is limited literature available on what is happening within the education sector holistically. By conducting educational external scans, through a one-case shot study, the findings from this research synthesize the current curricular requirements for the nations' baccalaureate graphic communication programs: including the number of programs, names of the programs, credit requirements, content area requirements, and concentration areas. The findings from this study provide valuable information for curricular developers on the current state of graphic communication education by synthesizing the curricular requirements.

Keywords: Graphic Communication, Curriculum Development, Curriculum Analysis

Introduction

Over the last decade, the graphic communication industry has seen advances in technology that have revolutionized the industry. Once dominant sectors of the industry have been transformed from ink on paper to content providers using various mediums. For example, Gannet Co., which once delivered news content primarily in print, now identifies as a "...subscription-led and digitally focused media and marketing solutions company" (2022). Although there is still traditional print happening within Gannett Co., to stay relevant within a transforming landscape they needed to make changes and embrace innovations (Shilpa, 2021).

This embracing of technology has long been foreseen. Over ten years ago researchers Webb and Ramono (2010) proposed ways in which commercial printers can stay relevant in the digital age. By embracing other forms of communication, Webb and Ramono (2010) defined how printing companies could move from traditional offset and binding into multifaceted communication companies offering a solution to all the clients' needs.

As the industry has seen vast changes, so too has higher education. And just like industry, as emerging technologies and adjusted workflows became relevant, institutions have made changes to their academic environment to keep pace with the industry. Once again this was identified early on by researcher Faiola (1999). Faiola discussed the need for a graphic communication education curriculum to evolve from analog to digital-based technology. Furthermore, a leader in graphic communication education, the Graphic Communications Education Association (GCEA), identifies in their GCEA Strategic Plan v4B (GCEA, 2018) the changing landscape and the need to stay relevant by moving on beyond the traditional print landscape and providing "more value by helping our members develop new skills that help them position for the future workforce demand" (p. 7).

As graphic communication programs have updated their curriculums, little has been done to identify the direction each program has taken. This study aims to identify an understanding of the current curricular requirements within graphic communication education programs at four-year institutions in the United States.

Literature Review

As a paradigm shift happens within graphic communication, the question arises: "What is graphic communication?" The National Center for Education Statistics NCES (2022) defines Graphic Communications as "A program that generally prepares individuals to apply technical knowledge and skills in the manufacture and distribution or transmission of graphic communications products". To clarify that further, the NCES (2022) identifies what those graphic communication products include, "instruction in the prepress, press, and postpress phases of production operations and processes such as offset lithography, flexography, gravure, letterpress, screen printing, foil stamping, digital imaging, and other reproduction methods."

When searching benchmark graphic communication program websites at 14 universities, findings revealed a variety of answers to "what is" graphic communication. Most answers incorporate traditional print with new media; for example, a California university website defines graphic communication as "the study of how we convey meaning through visual design. This includes the creation, production, management and distribution of advertising, marketing, websites, mobile apps, books, packaging and other media in printed and digital form" (2022). South Carolina identifies their Bachelor of Science in Graphic Communications as a program that "prepares students for professional careers in printing, publishing, packaging graphics, digital media, content creation, and the greater communication industry" (2022). Furthermore, South Carolina "takes a holistic approach moving students from creative concept to actualization" (2022). Whereas the Digital Media program in Houston describes its students in the program as "going beyond a single profession. They are strategists who produce across print, packaging, emedia, eCommerce, simulation, app development, videography, animation, game development, and photography" (2022).

Although programs may define graphic communication differently or take a distinct perspective to provide information to prospective audiences, at the core of graphic communication is the production of information through physical and digital media.

Curriculum Development

When higher education looks to the development or re-design of its curriculum it is done so with many influences in mind. Researchers Lattuca and Stark (2009) identify the influences that affect academic plans including external, institutional, and unit-level. Graphic communication educational programs have a strong tie to external influences. By nature, graphic communication degrees are developed due to the need of these external constituents, developing skill sets that are desired in today's job market is their focus. Often, these external constituents aid programs through an industrial advisory board by providing programs with in-depth industry knowledge, industrial advisory boards offer academic units assistance in the development of and assessment of curriculum, desired graduate learning outcomes, and feedback on program quality (Schuyler, et. al, 2001).

Furthermore, programs and institutions look to a peer-review process to validate their institution and programs. Accrediting bodies will not only identify if institutions and programs are meeting an acceptable level of quality, but they will also provide curriculum suggestions. Although, these are just suggestions, and most accrediting bodies steer clear of being prescriptive on content delivered through the curriculum. For example, the Council for Higher Education Accreditation (Eaton, 2015) states, "Institutional autonomy is essential to sustaining and enhancing academic quality" (Eaton, 2015, p. 6). Furthermore, specifically focusing on the graphic communication industry, the Accrediting Council for Collegiate Graphic Communication Inc. (ACCGC), the standard for curriculum states: "The program curriculum must exhibit the pedagogy and curricular diversity required to meet student learning outcomes" (Accrediting Council for Collegiate Graphic Communications, 2022). Typically, the student learning outcomes are set by the individual programs and industrial advisory boards.

When examining the institutional influences, the mission can serve as a source of vision for how a program may fit within the institution. The understanding of how a program fits into the institution's vision, strategic plan, and the relationship between the institution and the broader public it serves is first and foremost in the development process (Sevier, 2003).

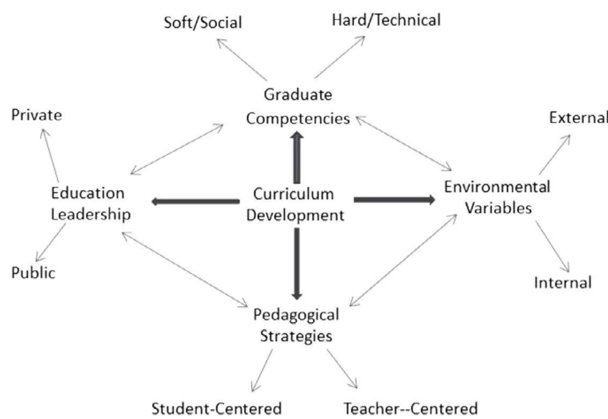
Faculty, administrators, discipline, and student characteristics are the drivers in the process and what Lattuca and Stark call unit-level influences (2009). Shared governance is fundamental to higher education, the process which includes the administrative board and faculty playing an integral part in the curriculum development process (Lattuca and Stark, 2009). As faculty play a key role, they can be influenced by external and institutional entities as well as their background (Stark, Lawther, Bently, and Martens, 1990). A framework to guide faculty in the process is critical.

Researchers Khan and Law (2015) propose a framework for the integrative approach to curriculum development which identifies a systemic approach to the development of the curriculum process. In a multi-stage model, Khan and Law (2015) suggest the need for environmental analysis, graduate competencies, curriculum development, pedagogical strategies, and implementation of the curriculum. Suggesting the curriculum development process should follow this integrative approach taking into account society, industry, government, and education institutions to develop a complete curriculum, step one of the process includes environmental scans.

Figure 1

An Integrative Approach to Curriculum Development

Note. This model was produced by Khan and Law (2015) from "An Integrative Approach to Curriculum Development"



The environmental scans include internal and external scans to identify "a comprehensive knowledge and understanding of what is happening in and around the educational institutions" (p.72). The external scans can establish a level of knowledge on what is currently happening within the specific arena of education.

When conducting external scans, curriculum developers are provided with a plethora of content from peer-reviewed journals and conferences observing competencies, skill sets, trends, techniques, and content. For example, when observing graphic communication education, the Visual Communications Journal and the Journal of Print and Media Technology Research provide a number of articles providing curriculum content within the graphic communication industry. Faculty can draw from articles on competencies such as Employers' Expectations of Graduates' Technical and Managerial Competencies in the Digital Graphics & Print Media Industry (Dharavath, 2019) and Competencies and tools of higher education graphic communications programs (Bridges, 2020). They can draw from articles that provide course content and techniques such as A Method for Creating and

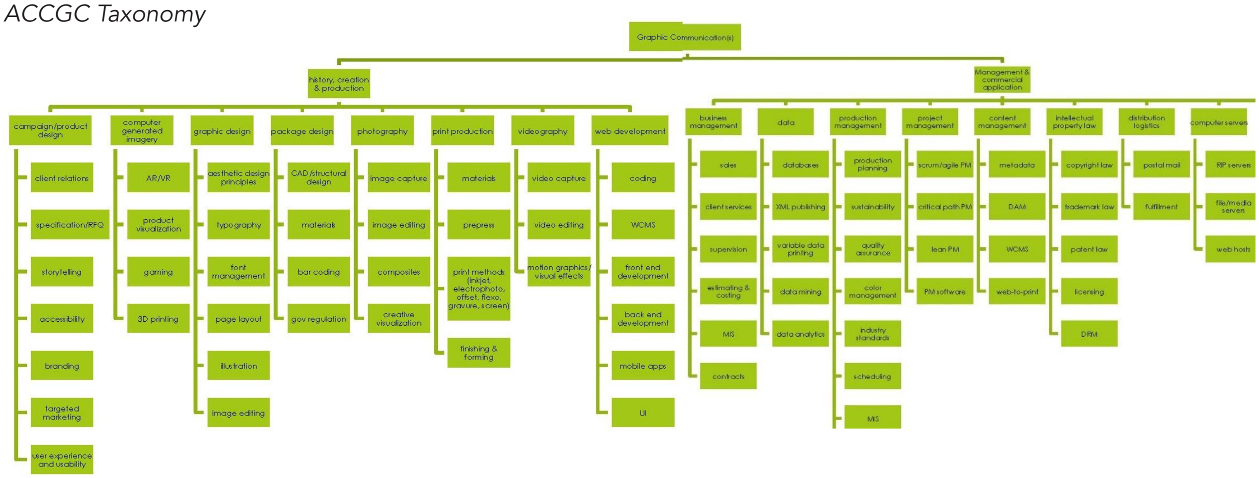
Using Time Standards for Cutting Tables (Wilson, 2020) and Special Techniques in Digital Photography (Lantz, 2016). Furthermore, there are articles on the trends in the industry and academics like Graphic Communications Curriculum: A Study of Courses Containing New Media Content (Anderson, 2004) and An Analysis on Industry Employment, Technology Trends and Program-Supported Activities (Lor, 2018).

Furthermore, Kahn and Law (2015) suggest curriculum developers conduct external educational scans to identify information regarding other institutions including the number of institutions of higher education functioning in the sector; the health of these programs, standards that may be focused on, and models of content and delivery. Furthermore, the external education scan identifies "collaboration versus competition among different schools inside the university; changes in structure and strategies, the level of institutional support for new program innovation; introduction of new educational models; and, establishing new academic standards so and so forth" (p. 69-70). There is currently a gap in the literature regarding external scans of the current state of graphic communication education, for example, the number of programs, major requirements, emphasis/concentration areas, and curricular focus.

In addition to Kahn and Law's (2015) framework on the curriculum development process, researchers sought a model to frame the graphic communication curriculum to identify the variety of knowledge areas taught within graphic communication programs. In 2022, ACCGC established a definition and Taxonomy of knowledge areas within graphic communication education (Accrediting Council for Collegiate Graphic Communications, 2022). Providing a broad definition of graphic communication education ACCGC's definition states, "A branch of technology with focus on the history, creation, production, management, and commercial application of visual products in digital and physical form. The study may include combinations of business management, computer generated imagery, computer servers, content management, data, distribution logistics, graphic design, intellectual property law, networking, package design, photography, print production, visual product design, production management, project management, videography, and web development" (p. 1). Although this study did not use the newly developed ACCGC definition as a definition to establish parameters for identifying graphic communication, researchers felt it was appropriate to use the Taxonomy as a framework to establish the parameters for coarse categorization. See Figure 2 for ACCGC Taxonomy.

ACCGC (2022) taxonomy of graphic communication education knowledge is divided into three levels. The first is the main categorization of knowledge areas: history, creation, and production and management & commercial application. The second level establishes subcategories with a broad grouping of specific knowledge areas. The second level includes business management, computer generated imagery, computer servers, content management, data, distribution logistics, graphic design, intellectual property law, networking, package design, photography, print production, visual product design, production management, project management, videography, and web development. The third level of the taxonomy

Figure 2
ACCGC Taxonomy



Note. ACCGC Taxonomy (ACCGC, 2022)

provides a very content-specific knowledge area. To conceptualize this framework for this study, the second-level subcategories were adopted as course categories for grouping. Although the ACCGC provides a baseline for the categorizing of courses, researchers identified issues when categorizing introductory courses that cover multiple second-level groupings, oftentimes in education programs have courses that are introductory to the industry/major covering multiple topics within. To address this, an additional category called Introductory/More than one topic was implemented. In addition, ACCGC's Taxonomy does not address courses that integrate the use and learning of knowledge through experiences; for example, practicum, internship, cooperative learning, senior design, etc. To address these courses a category labeled "Integrative Studies". Lastly, a category identified as "Other" was created for any courses that did not fit the parameters of ACCGC's Taxonomy.

Purpose

The purpose of this study was to examine the nations' baccalaureate graphic communication programs to synthesize current curricular requirements. This study explores the number of graphic communication programs, names of the programs, credit requirements, course requirements, and concentration/minor tracks. This data is intended to inform and assist institutions in the curriculum development of graphic communication programs.

Limitations to the study

The data collection process led to a limitation in this study. All data were obtained through the university website, which may not be an accurate representation of actual student requirements. The researchers recognize that academic program changes may be done without advertising it on the website or updating the course catalog.

The categorizing of courses into the taxonomy framework was done using the course title and description posted on the university website. Title and description is not always consistent with course content leading to a limitation of this study.

The composite curriculum created as a result of this study was based upon existing curriculum requirements for those programs included in the study. As such, it is simply a composite curriculum of what exists now.

Methodology

To obtain data regarding baccalaureate graphic communication programs a one-shot case study was performed. The one-shot case study allows researchers to conceptualize a moment in time (Campbell & Stanley, 2015).

Population

The target population was all baccalaureate granting institutions in the United States that offer a degree program in the graphic communication industry. To identify a population, frame the online published Print and the Graphics Scholarship Foundation Directory of Schools was utilized. The list was examined and narrowed down to baccalaureate granting institutions only. The list was further narrowed to programs that fit under the category of traditional graphic communication programs. The identification of traditional graphic communication programs was done by using the NCES definition of graphic communication education:

A program that generally prepares individuals to apply technical knowledge and skills in the manufacture and distribution or transmission of graphic communications products. Includes instruction in the prepress, press, and postpress phases of production operations and processes such as offset lithography, flexography, gravure, letterpress, screen printing, foil stamping, digital imaging, and other reproduction methods. (National Center for Higher Education Statistics, 2022)

Using this definition, the research team examined each baccalaureate granting institution's curriculum and identified 18 programs with a focus on graphic communication. Three additional programs were identified to have a graphic communication concentration as part of a related degree; researchers did not include those three programs in the study. Three programs were removed from the study due to currently suspended enrollment. One program, a Bachelor of Applied Science, was removed due to the 2+2 inverse-curricular model, resulting in 14 graphic communication focused programs used in this study.

Data Collection Procedures

After the identification of the programs, further data was collected by gathering information listed on each institution's website. Programs of the study were sought, and when no program of study could be obtained the data was gathered from the institutions' course catalog and/or program informational webpage.

Data Analysis

The data collected from the institutions' websites were analyzed in the following manner.

The required credits within the program were categorized into degree, major, general education and electives. General education credits that were also required by the major were categorized into general education. If a program required a specific minor, those courses were counted in the major requirement area. For example, a program that requires a general business minor would have the general business minor courses counted towards the major requirement credits.

Each required course within the institutions' programs was further analyzed to identify the course content focus. To categorize courses researchers analyzed the course title and descriptions posted in the program of study, website, and/or course catalog. Once the course focus was identified, it was then categorized into the second level of the ACCGC Taxonomy. To account for educational courses that did not fit into the taxonomy, researchers included three categories including introductory/more than one topic, integrative studies, and other. The identification of the number of programs with required concentration tracks and/or minors was collected, and each concentration and the minor title was determined and recorded as found.

Results

Number of Programs and Program Titles

A total of 14 graphic communication programs were found. Of the 14 programs, three had the title Graphic Communication(s), and two used Graphic(s) Technology. The remaining nine programs had titles unique to their institution. The complete list of program titles is found in Table 1.

Table 1
Institutional Graphic Communication Program Names

Program Title	Number of Programs using Title
Graphic Communication (s)	3
Graphic(s) Technology	2
Graphic Communications Technology	1
Digital Media Technology	1
Digital Media	1
Graphic Arts Management	1
Graphic Communications Management	1
Graphic Information Technology	1
Graphic Communications Media	1
Graphic Media Management	1
Media Arts and Technology	1

Credit Hour Requirement

A summary of program credit hour requirements in degree, major, and general education are found in Table 2. The total mean number of degree requirements was 125.6 (SD=15.5) with a minimum of 120 and a maximum of 180. The total mean number of credits required within the major was 70.6 (SD=19.3), this includes concentration and required minor credits. The total mean number of credit hours required within general education was 43.3 (SD=9.3). The total mean number of credit hours required within elective hours was 19.4 (SD=20.2).

Table 2
Baccalaureate Graphic Communication Credit Requirements

Course Classification	M	SD	Mode	Mdn	Min/ Max
Degree Credit Hours	125.6	15.5	120	120	120/180
Major Credit Hours	70.6	19.3		74.5	38/108
General Education	43.3	9.3	42	42	29/72
Electives	19.4	20.2	0	14.5	0/72

N = 14

Coursework Concentration

A research objective was to describe the required course content focus areas. This was done using ACCGC's Taxonomy of content areas. A summary of credit hours within the ACCGC's Taxonomy of courses is presented in Table 3.

Print Production was the highest category (M = 10.1, SD = 6.4) followed by Business Management (M = 6.1, SD = 4.1), Integrative Studies (M = 5.0, SD = 2.7), Introductory/More than one topic (M = 3.9, SD = 3.1), Photography (M = 3.5, SD = 1.9), Campaign/Product Design (M = 3.4, SD = 3.2), Production Management (M = 3.1, SD = 3.3), Graphic Design (M = 3.0, SD = 2.8), Web Development (M = 2.8, SD = 1.8), Package Design (M = 2.4, SD =2.6), Data (M = 2.0, SD = 3.0), Project Management (M = 1.1, SD = 1.8), Other (M = 0.9, SD = 1.4), Videography (M = 0.9, SD = 1.8), Computer Generated Imagery (M = 0.4, SD = 1.0), . No courses were categorized in Content Management Systems, Intellectual Property Law, Distribution Logistics, Computer Servers, or Networks.

Concentration Areas

When examining if programs have specific concentration/tracks outside of the required major courses six of 14 programs required students to choose at least one concentration/track. The concentration areas list is provided below; they were not categorized in ACCGC's Taxonomy due to the interdisciplinary nature of many concentration areas.

- Marketing Graphics Technology
- Digital Media
- Graphic Communication Management
- Print/Packaging Production
- Web Design & Development
- Networking Information Technology
- Web Content Management
- Graphic Design
- Graphics for Packaging
- Cross Media Production
- Commercial Photography & Video
- Interactive Computer Graphics Technology
- Graphics Management
- User Experience/User Interface
- Digital Design, Print, and Publishing
- Packaging Graphics
- Design Reproduction Technology
- 2D/3D Animation
- Print Media
- Web/Interactive Media
- Photography
- Print

Table 3

Course Classification

Course Classification	M	SD	Mode	Mdn	Min/Max
Print Production	10.1	6.4	15	9.5	0/21
Business Management	6.1	4.1	3	6	0/12
Integrative Studies	5.0	2.7	6	5	0/9
Introductory/More than one topic	3.9	3.1	3	0	0/12
Photography	3.5	1.9	3	3	0/9
Campaign/Product Design	3.4	3.2	3	3	0/12
Production Management	3.1	3.3	3	3	0/12
Graphic Design	3.0	2.8	3	3	0/9
Web Development	2.8	1.8	3	3	0/6
Package Design	2.4	2.6	0	1.5	0/6
Data	2.0	3.0	0	0	0/9
Project Management	1.1	1.8	0	0	0/6
Other	0.9	1.4	0	0	0/3
Videography	0.9	1.8	0	0	0/6
Computer Generated Imagery	0.4	1.0	0	0	0/3
Content Management Systems	0	0	0	0	0
Intellectual Property Law	0	0	0	0	0
Distribution Logistics	0	0	0	0	0
Computer Servers	0	0	0	0	0
Networks	0	0	0	0	0

N = 14

- Interactive
- Video

Three programs required students to complete at least one minor from an approved list. The approved minors included:

- Applied Innovations
- Technology Leadership and Innovation Management
- Business Administration
- Studio Art
- Advertising/Integrated Marketing Communications
- Computer Information Systems
- Digital Marketing
- Human Resources Management
- Integrated Marketing Techniques
- International Business
- Leadership and Project Management
- Lean Systems
- Marketing Sales
- Public Relations
- Small Business Entrepreneurship

One program required a General Business minor.

Conclusion, Implications, and Recommendations

Graphic communication education programs across the United States have been adjusting curricula to align with a transforming industry yet little has been done to document the changes. This study sought to provide a census of graphic communication education to provide a baseline for comparison of future curricular changes across and among graphic communication programs. A significant finding the researchers identified was the number of programs and titles. Although historical data was not included in this study to identify how this has changed over time, researchers found the number of programs that have closed or have suspended enrollment could be significant. During the data collection procedures for this article, three different programs that suspended enrollment announced closure of suspended enrollment. All through this study conducted a one-shot case study to capture this current moment in time, it is a recommendation of the team to identify history data of graphic communication programs to identify how the landscape has changed over the years.

The variation of program titles is another significant finding from this research. Three programs used the traditional title of Graphic Communication(s), two programs used Graphic(s) Technology, and nine of the 14 identified programs had unique names for their institution. Although there was not much agreement in program title, a theme in terminology was found: programs typically hovered around graphic(s), communication(s), technology, media, and management. This finding has vast implications for the identification of graphic communication education. Without a common program title, graphic communication education has developed an identity crisis, which seems fragmented without a clear direction.

The course classification using ACCGC Taxonomy as a frame was helpful in providing a baseline for the focus of graphic communication programs. As expected, Print Production was the most common course taught, followed by Integrative Studies, then Business Management. These findings show program curriculums are still within the core of graphic communication education. When reviewing this data, a theme started to become apparent to the researchers, programs are typically introducing students to the industry, teaching them the core knowledge areas then integrating those skills in various hands-on courses such as internship, cooperative learning, and senior designs.

The identification of concentration and approved minors provides a glimpse into how programs have established industry-specific areas as well as interdisciplinary aspects into their program. All the required concentration areas found in this study are closely related to graphic communication and many of which are directly tied to the evolution of the industry. For example, a majority of the concentration areas are within areas that did not exist in the graphic communication of the past for example User Experience, 2D/3D Animation, and Web/Interactive Media. As a major trend in higher education is to include interdisciplinary curriculum, this study provides curriculum developers with the identification of related interdisciplinary majors.

Although this study did not seek to identify programs that used graphic communication as a concentration researcher felt the identification of three programs with a concentration in graphic communication is a significant finding. As institutions' budgets become tighter and program cuts continue an upward trend, the addition of graphic communication concentration within other majors is an adequate way to keep a graphic communication education within an institution's curricula. Using the findings from this study and the course classification as a baseline, it is the researchers' suggestion for programs looking to develop a concentration in graphic communication to include a series of credits in Print Production, Integrative Studies, and Business Management.

The credit hour requirements among the studied group were as expected. Although the findings were slightly skewed due to one outlier overall, the mean of 67 credits required within the major, 43 in general education, and 20 in electives is aligned with a majority of Bachelor of Science/ Bachelor of Arts programs in the United States.

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What is the Environmental Impact of your Messaging?

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Abstract
As Light Emitting Diodes (LEDs) and Liquid Crystal Displays (LCDs) are increasingly used as a dynamic alternative to paper signage, the environmental impact of power usage is frequently overlooked. The author of this paper reviews the environmental impact of LED and LCDs and provides information gained from the adoption of the ultra-lower power consumption of e-Ink technology as an alternative.

Keywords: Light Emitting Diodes, environmental impact, e-Ink, digital signage.

Introduction

Electrical Power Usage

According to the U.S. Environmental Protection Agency (EPA) (2018), almost all components of the electrical power system can impact the environment. These effects depend on how and where the electrical power is produced and delivered. The most common resources where energy comes from are natural gas, coal, and nuclear power, with most electricity in the United States generated in centralized power plants. This generated energy is used predominantly in three sectors, industrial, residential, and commercial, along with a minuscule amount for transportation.

Electrical power travels from power plants to buildings by the power distribution grid; nearly all such power in the United States is generated and transmitted as altering current. The alternating current has an oscillating power wave of transmitted current. This discovery makes power distribution more efficient and available. The most common power outlets in the United States are 120-volt alternating currents.

Importance of Environmental Impact of Electrical Devices

"Electricity generation is the single largest source of greenhouse gas emissions in the United States" (EPA 2015). The environmental effects of the electricity system are profuse. Greenhouse gas and other air pollutant emissions can occur when fossil fuels burn. When used to produce steam, cooling, and other functions, water can discharge pollution into bodies of water. Both toxic waste and thermal pollution can occur. Solid waste, including hazardous waste, can endanger living species. Air, water, waste, and land impacts may affect plants, animals, and ecosystems. Changes in our electricity use can reduce all these environmental effects.

Energy Efficiency and Sustainability

Various approaches have been proposed for energy efficiency in messaging. The U.S. Environmental Protection Agency recommends that consumers minimize electrical usage: "End-users can meet some of their needs by adopting energy-efficient technologies and practices. In this respect, energy efficiency is a resource that reduces the need to generate electricity" (EPA 2015)

The path to energy efficiency can include saving costs, supporting the environment, and creating a better future. As Fernandez et al. (2015) mention, the International Energy Agency (IEA) aims to reduce the global consumption level to an acceptable limit and calls for more efficient technologies. They point out that technologies can and must play an integral role in transforming the energy system to reduce greenhouse gases. The focus of improvement needs to shift to making devices more power-efficient, and display technologies need higher levels of energy efficiency.

LED/LCD/Plasma Displays for Digital Signage

LED/LCD/Plasma displays have become ubiquitous in recent years and can be found in individual homes, businesses, public buildings, and institutions, including colleges and universities. In recent years, the dramatic decrease in costs for LCD, LED, and Plasma displays have forever changed home televisions and made using these devices for indoor signage applications feasible. These devices can be easily updated, and content is kept current, aided by wireless connectivity. As a result, devices are frequently used as an alternative to printed displays in buildings trafficked by people: retail spaces, offices, hospitals, and educational institutions, to name a few. In the Sustainability Implications of Organic User Interface Technologies: An Inky Problem, Blevis (2008) explains how these computing technologies have helped in minimizing paper usage. Many young students and millennials prefer to read from a screen rather than paper, however, a large population still prefers to read print for different circumstances (Baron 2017). There are many advantages to using technology displays, including dynamic content, and decreasing the environmental cost of paper production. Nonetheless, "increasing demands for a technology can drive down some such environmental costs while increasing others" (EPA 2015).

The electrical current to power these devices, and its subsequent environmental impact, are often overlooked. The present study uses an e-Ink display, which features extremely low power consumption, for an indoor signage application.

Uses in Colleges and Universities

Many commercial establishments and institutions like colleges and universities use LCD/LED displays for dynamic signage throughout their buildings. The Frank E. Gannett Hall at the Rochester Institute of Technology's campus contains nearly 20 LCD/LED displays. These displays continuously run 24 hours a day, seven days a week. For one display to power at 65W all day, the Rochester Institute of Technology is using 1.5kWh. In a month, the Rochester Institute of

Technology is using 46.8kWh. Multiplying that value by the average cost for power in New York State of $.2158, the electricity bills every month is $10.10. Considering the 20 displays in the Frank E. Gannet Hall, the monthly power cost of all these displays is $202, and for a year, $2,424. One can imagine the cost for buildings across the entire Rochester Institute of Technology campus.

These significant emissions of power generation are concerning, not just in terms of monetary value but also in environmental impact. Exploring low-power consumption alternatives is, therefore, timely and relevant.

e-Ink Technology, a Low Power-use Alternative

About

e-Ink, also referred to as electronic paper (e-Paper), can be considered the superior choice of display technologies in terms of energy consumption, advertised as 99% more energy efficient than comparable solutions. Many refer to the e-Ink display as a "giant Kindle," as the technology utilized is the same as the popular e-book reader. The goal of e-ink is described as "a technology that mimics the appearance of ordinary ink on paper (Primozic 2015). Primozic continues to say that the e-Ink displays have "excellent visibility and paper-like readability while consuming very low amounts of energy, making it a perfect choice for many different and extraordinary products". French (2020) lists, e-ink's advantages as consuming far less power than any other display technology to date, can display content for an extended period without power, and is easy on the eyes even when outdoors and in direct sunlight.

These displays utilize Electrophoretic Technology, simply meaning that it functions based on the motion of dispersed particles in a fluid under the influence of an electric field. e-Ink displays contain millions of capsules in a thin film. Both positively charged white ink particles and negatively charged black ink particles are inside those capsules. When a positive or negative electric field is applied to an individual electrode, the corresponding color particle will be attracted to either the front of the display or the back. Those ink particles at the surface of the display appear as the color they contain (Fernandez et al. 2015) "The displays can hold static text and images for a month without electricity and retains them when the power is off" (What Is E-Paper Display? 2020).

Commercially Available Solutions

There are a handful of companies that commercially sell e-Ink products. The leading developer selling exclusively e-Ink digital signage displays is Visionect®. Visionect® was founded in 2007 to produce ultra-low-powered digital signage solutions that are green, sustainable, and accessible.

Visionect

Place & Play® is advertised as an all-in-one signage system with the display, player, and mount. They are cord-free, making installation nearly effortless. Their system supports all major content management systems and can easily display any web link. The design is very paper-like and is built to have a smooth look and feel.

Specifications.

Figure 1 includes the 32" Place & Play® product technical information on the Visionect® shop website.

Figure 1

Technical Information 32" Place & Play.
Found on the Visionect Shop Website

Technical information

Software & license

Includes access to the Visionect Software Suite, in charge of running an elec

- Universal web CMS support. Easily display any web link, allowing for compatibility witl
- Improved screen content performance and intelligent screen updates.
- One-stop device management. Upload images, edit device settings, access analytics,

Display

- 31.2-inch (16:9 diagonal) E Ink® electronic paper screen
- High visibility and contrast
- 180° viewing angle
- Resolution: 2560 × 1440px
- Active Area (H/W): 27.21 × 15.31 in. (691.2 × 388.8 mm)
- Pixel Pitch (H/W): 0.01 × 0.01 in. (0.27 × 0.27 mm). Equivalent to 94 ppi.
- Pixel Configuration: Square
- 16 level grayscale
- Refresh rate: 750 ms (4 bit full screen) / 100 ms (1 bit partial)

Connectivity

- 2.4 GHz Wi-Fi (IEEE 802.11 b/g/n) standard, WPA2-PSK, WPA2-EAP support

Power

- Patented ultra low energy architecture, only 1% of the power used by LCD.
- High performance rechargeable battery.
- Enclosed Micro USB charging cable
- Cordless functionality

Casing

- High quality anodized aluminum casing.
- Anti-reflective, high transmissive glass.
- Color: Slate Gray, Graphite Black

Dimensions & weight

- 27.84 × 16.29 × 0.53 in. (707.20 x 413.80 x 13.50 mm)
- Weight: 8kg

Mounting

- 7.87 × 7.87 in. (200 × 200 mm) VESA mount compliant.

Environmental conditions

- Operational and storage temperature range: 32°F to 122°F (0°C to +50°C)

In the box

- Visionect Place & Play 32"
- 1 x Micro USB cable for configuration and charging
- 1 month of free server hosting
- Access to the Visionect Software Suite

Product support

Want to know more? Consult our comprehensive Knowledge Base.

Limitations

With all the advantages that Visionect®'s Place & Play® gives, their products have some limitations. While e-Ink display technology is as easy to set up and use as other types of displays for indoor signage applications, uses far less electrical power, and does not need to be plugged in, it is not a replacement for other technologies in every application.

Size

The variety of sizes is not as comprehensive as many other display technologies. Visionect® currently markets two Place & Play® sizes: 13" diagonal and 32" diagonal) Different types of display technologies offer myriad sizes, including pocket-sized like a smartphone to huge flat-screen televisions

Initial Cost

Foremost among the disadvantages of e-Ink technology is the initial cost. The Visionect Place & Play 32" costs nearly $2,600.00 and is shipped from Slovenia. Similarly, sized LCDs are readily available at common retailers and can be purchased for less than $200.00.

Although these costs may seem discouraging, the initial installation costs and the long-term savings in terms of power consumption should be factored into a cost of ownership analysis.

Monochrome

The tonality and colors of an e-Ink display are limited. Specifically, the Place & Play® products can only reproduce a 16-level grey scale. This can hinder the amount of content that can be shown, as well as affect the images that are presented. Some images may appear posterized due to the limited grey scale range of this technology.

Although there has been technology created to produce colors on e-Ink displays, the Place & Play® is limited to grayscale.

Refresh

The e-Ink display has a longer refresh rate when compared to LCDs. The Place & Play® display completely clears the original image to prepare for the new image. A reset process of black and white is observed that allows the technology to identify what charge the electrodes need to produce. The refresh rate of Place & Play® is .75 seconds (75 ms), while the average refresh rate for a LED/LCD is from 0.008 to 0.017 seconds (8-16 ms). This results in a noticeable refresh difference, but for signage applications, the refresh rate of the e-Ink technology specifically for static images is not deterring. The extended refresh rate of the e-Ink technology effectively limits the display to static images; video images and moving graphics are problematic with e-Ink displays. If a display were to mainly exhibit video-based or frequently updating social media content, other displays including LED/LCD would be a more reliable and stable choice as per their capabilities.

The limitations of e-Ink displays notwithstanding, there are still many advantages mentioned that all meet the Graphic Media Science and Technology needs. As a result, the Graphics Media Science and Technology Department implemented a Visionect® e-Ink (Electronic Ink) display in a public area. The remainder of this paper describes the process of implementing this technology.

Implementing Visionect® e-Ink Technology for Digital Signage

The process of adopting the e-Ink display includes the purchase, set-up of the hardware, and connecting the device to the wireless network.

Purchasing (Hardware and Software)

A 32-inch "Place and Play" e-Ink display was purchased from Visionect in Slovenia. The 8 kg. display ships with a standard micro-USB connection cable for charging; when mounted, it is completely cord-free, can run for weeks between charging sessions, and can easily be charged with a portable power bank. The display includes access to an easy-to-use Visionect Software Suite, which facilitates providing content to the device once it is recognized on a wireless network. The display can show web pages or png or jpeg graphics, and the user can set the interval for how long each image is displayed. There are additional fees when shipping from Europe to the United States and a Value-Added Tax was imposed. Unboxing the Visionect was captured as shown in Figure 2.

Figure 2
32" Place & Play® Unboxing

Set up, Initial Charging

To set up the Visionect Place and Play® the user downloads and runs the Visonect Configurator software to connect to their wireless network.

Controls on Device

The device itself is very sleek and flat. Instructions include how to connect the display to a wireless network. There are no buttons or controls found on the display itself.

Connecting to the Network

Connecting and configuring the Place & Play® began by plugging the micro-USB cable into the Place & Play® and the USB port to the computer. The next step was to download the Visionect® Configurator, which can be found on the Visionect® Getting Started page. Once the Configurator was downloaded and running on a local server, the Wi-Fi connection details were entered. Although the use of Wi-fi power was not taken into consideration when Once the device was configured, the Visionect® Software Suite could be accessed.

Using the Software

The Visionect® Software Suite is "in charge of all the operational aspects of running an electronic paper sign" (Visionect 2019). The interface allows users to access images, edit device settings, view analytics, and more. The Visionect® Software Suite can be accessed through any supported Internet browser.

The suite is very convenient and accessible. The devices online can be found on the main page with a preview of what is being displayed on the devices. Once clicking the specific device, changing the content displayed is easy. There are two different content choices: either an image or a web page.

The system supports advanced and complex content display scenarios, including display tiling in which multiple displays can be placed next to each other for dramatic effect. However, the current project aimed is to use the display to rotate static images, which include text and graphics of departmental news and announcements.

To facilitate adoption, the researcher created several templates using Microsoft PowerPoint, together with detailed standard operating procedures (SOPs) so that a user of any design experience, graduate or not, could simply edit the text and graphics in PowerPoint, save the resultant image as a png graphic, and bring it into the Visionect Software Suite to update the display. Various displays that will be frequently used and not changed were designed in Adobe Illustrator and InDesign. As previously mentioned, the time interval that each image is displayed is intuitively set in the Visionect Software Suite.

Static Images

If the desired content is a static image, one can easily upload a chosen image to the Visionect® Suite Gallery, where multiple files can be stored. The file formats that can be uploaded are png or jpg. After being uploaded to the gallery, it is stored there and can be referred to as often as desired. Users can also select many images to cycle through and specify how long for which an image will be displayed.

File Format Types.

Due to the suite's limitations of image file formats of png and jpg, content can be developed in applications that allow images to be exported and subsequently converted to the appropriate formats.

Colored images or designs do not need to be converted to a grey scale. Although the screen will not render the colors, it will modify for its own limitations. This adaptability of the Place and Play® is convenient, but as mentioned before images may appear posterized due to the limited grey scale range of this technology. If the posterized image is not to the users liking, the image can then be converted to a proper grey scale.

Dynamic Web Pages

If a webpage is to be displayed, users can select "Display web page" and enter the URL that the user wishes to be displayed. The webpage can be as simple as Google.com or a dynamic web page HTML. Despite the Place and Play® capabilities in displaying a webpage, the colors and motion elements are still limited.

Imagine Rochester Institute of Technology Experience.

The researcher showed the e-Ink display at the (university name) Imagine Festival in April 2022. To make the presentation interactive, a web page was set up to show a simulation of a newspaper page highlighting the festival, and attendees were invited to upload a picture from their mobile phones to the website. Attendees were asked to scan a Q.R. code, which accessed a web page where they could choose a photograph and upload it to the server. With the image uploaded, the HTML/JavaScript page shown on the e-Ink display would refresh, and the attendee's image replaced the previous photograph in the newspaper displayed. The choice of newspaper page imagery highlighted the paper-like readability of the e-Ink display. Figure 3 shows the researcher with the Visionect Place & Play® displaying the newspaper page with uploaded pictures from attendees.

Figure 3

Researcher with the 32" Place & Play®

Recharging the Device

Since purchasing in March 2022 and receiving the Place & Play®, it has been fully charged twice. Charging the display is as like charging any other cellular device. The provided micro-USB charging cable can be plugged into the back side of the display and then plugged into any USB charger or alternating current. Like LED/LCDs, this e-Ink can also be directly connected to any power outlet in the building. This technology does not consume as much power as other technologies do; however, this would not be the best choice in terms of energy efficiency and would not fully support the goal of taking steps to a greener initiative.

Using External "Cell Phone Charger," Possibly Solar Powered.

In thinking about the future, it is important to be vigilant about power usage. It is therefore essential to consider other options for charging the device. One idea is to use a solar powered "cell phone charger" to power the device rather than connecting it to the power grid. Due to its minimal charging requirements, the solar-powered charger can be stored with access to direct sunlight when not used to recharge the Place & Play® device.

Conclusion

Use for Digital Signage in College/University Settings

Given the limitations, the e-Ink display can be a viable alternative to the more common LCD, LED, and Plasma displays in many, but not all, applications. This is especially true when AC power is not readily available, and concerns about environmental impact are paramount.

The successful implementation of an e-Ink display for digital signage opens the possibility of using this technology to substitute more LED/LCDs on campus. This technology is best used for informative displays, calendar events, and messaging.

As LED/LCDs are often implemented to use less paper, this transition into e-Ink would also meet this goal and decrease energy usage. Instead of multiple flyers printed for a department, each design for a flyer can be uploaded and interchanged on this e-Ink display.

Many computer labs on campus use small LED/LCD displays that show the weekly schedule of the lab and when students can access open lab hours. This simple messaging technology can be used for straightforward messaging like these lab schedule displays.

Other Commercial Applications: Transit Signage, Typically with Solar Panel

As this technology immerses itself in society, e-Ink is used as transit signage in many countries in Europe, Australia, and in American cities like Boston and Austin.

Upon landing at Auckland airport, travelers are greeted by Visionect e-paper products (Visionect, 2019). Visionect Urban® signs were installed at Auckland's bus stops in 2018. These e-paper screens provide "Real Time Passenger Information (RTIP) to commuters" (Visionect, 2019).

Similarly, transit agencies in Boston, MA, and Austin, TX have adopted e-Ink displays. Austin, TX installed over 148 e-paper displays in early 2020 at rail stations, bus stops, and parks and rides. "Because the e-paper displays can be updated remotely, Capital Metro can push automatic updates and ensure rider access to up-to-date information" (Eink, n.d.). Solar-powered e-Ink signs are being experimented in Boston, MA, and will be evaluated based on durability and performance. Customers continue to provide feedback, which will ultimately "determine whether signs should be used at additional bus and subway stops" (Eink, n.d.)

This revolutionary technology can run on a solar panel-powered system and continuously exhibit the required information, with ultimately no need for generated power (Primozic, 2016), and is demonstrated by Auckland airport Urban screens (Visionect, 2019). As more manufacturers of e-Ink technology enter the market, the initial pricing will likely decrease, making the technology more affordable for many potential applications.

Similar to Visionect, the company E Ink has installed this technology into their innovative interior design (Innovative Design, 2020). Their products, the E Ink SurfTM and E Ink PrismTM can combine colors, overlays and patterns to integrate itself into the building's architecture. These products are now found in various locations including, educational, healthcare and hospitality. Creating an enhancing and interactive wall in these buildings, E Ink products can change a static painted white surface into a "one of a kind experience" (Innovative Design, 2020) with low power consumption to help meet their sustainability goals.

Barrett Comiskey, who has been called the "father of electronic ink" (Primozic, 2016), explains the future of e-Ink as a long road ahead, but in an open-ended way. This technology has a particular role in the signage industry. Although it isn't interchangeable with LED/LCDs in all applications, it will continuously offer a more calming, organic, low-power experience for any consumer.

Closing

The researcher would like to thank Rochester Institute of Technology's Joel Yates for his IT support in getting the e-Ink display connected to the network and Prof. Graham Anthony is his support in developing the web page and smartphone application for using the display at the Imagine festival. In addition, the researcher thanks Dr. Malcolm Keif and Dr. Bruce Leigh Myers for their advisement on this project. As shown in Figure 4, the Visionect Place & Play® is now mounted on the wall of Rochester Institute of Technology, Frank E. Gannett Hall building displaying infographics, news, event flyers and student work.

Figure 4

32" Place & Play® in Frank E. Gannet Hall

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Students' Perceptions of Utilizing Purpose-Made CAD Videos for 3D Printing During COVID-19

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Abstract
As a result of the COVID-19 pandemic, the world was forced to stay at home. This study looks at how students perceived the changes made to a course previously involving a heavy emphasis on in-lab instruction in the use of 3D design software. Due to the steep learning curve for beginner users of computer assisted design (CAD) software, purpose-made videos were created to assist students. These video tutorials allowed students to better manage their learning by using the videos to their advantage. These short thematic videos allowed students to pace their learning by watching these videos as many times as needed at the student's leisure. The students were given a survey at the end of the course. The survey results were positive.

Keywords: Emergency Remote Teaching, Computer Aided Design Software, CAD, 3D Printing, Online Learning, COVID-19 Pandemic, Thematic Purpose-Made Videos, Asynchronous Learning, Parametric Modeling.

Introduction

This study took place at Toronto Metropolitan University. The subject of this study is a full (winter) semester academic course consisting of 50% lecture and 50% hands-on lab learning. This popular university open elective is an introductory 3D printing course that attracts interdisciplinary undergraduate students from a range of programs (Table 1).

The large class has lectures of approximately 100 students, while lab sections consist of 15 to 18 students. In lecture, students are introduced to the technology and its history. In the lab, students gain an introductory hands-on ability to model 3D objects using direct, parametric (CAD), and organic sculpting software. Models are, then, output on 3D printers.

Background

Instructors of creative and technical software often take a one-size-fits-all approach to teaching hands-on use of these programs in a computer lab. This is despite the fact that students have different learning styles—Auditory, Visual, and Kinesthetic.

Auditory learning is a learning style in which a person learns through listening. Visual learning is a learning style where a learner needs to see information in order to process the information. Kinesthetic learning is a learning style in which learning takes place by the students carrying out physical activities. Auditory, visual, and kinesthetic learners are very different in how they process information and learn in vastly different ways as well as at different speeds.

In-class teaching of technical software use can be challenging at any time. There is a common approach that is taken to teaching highly technical software like computer assisted design (CAD) in person. While students sit behind a computer in a lab, the instructor teaches from either the front or the back of the room. As the instructor demonstrates live on their own computer, the steps are projected on a screen. Students are expected to listen to the instructor, observe what is happening on the display screen, while at the same time performing the steps on their own computer, and taking notes. These are four activities that students must perform simultaneously. It can be challenging to watch a projection screen while looking at your own computer monitor. The steps may or may not be repeated by the instructor. A large number of steps may be demonstrated at one time. After the demonstration, time is usually given for students to practice and complete assignments. Students are, then, expected to remember the many steps, learn all of this by applying it in projects and possibly responding to related examination questions.

For some students this multi-tasking poses no problems at all, but for other students this may be very challenging. Due to a student's natural auditory, visual, or kinesthetic learning style, the result is that some students struggle to keep up. Students may not signal to the instructor when they are behind. They could be shy or feel embarrassed to speak up. There may also be peer pressure that may cause students to not ask questions aloud in class. Other students may have issues with language comprehension. With in-lab learning, students may be more apt to ask the student next to them for assistance rather than publicly requesting assistance. Relying on a classmate may not be possible when learning online.

During the work period that follows the laboratory instruction, the instructor and teaching assistant (TA) will usually circulate around the room to get a gauge on how students are doing and to assist them as necessary. This is a good way to get to know the students. If a student has a problem or is unable to perform an operation, the instructor or TA will provide verbal instruction. If this verbal instruction is insufficient in assisting the student, the instructor or TA can simply take hold of the mouse and demonstrate the

Table 1

A List of Students' Home Program of Studies

Architectural Science	Arts & Contemporary Studies	Biomedical Engineering
Business Technology	Computer Science	Creative Industries
Environment & Urban Sustainability	Fashion Design	Financial Mathematics
Graphic Communications Management	Image Arts (Photography)	Interior Design
Media Production	New Media Studies	Nutrition & Food Management
Professional Communication	Retail Management	Sports Media

procedure. In online teaching, some of these problems may be more difficult to perceive and to rectify.

Literature Review

Many previously published studies have been framed through the Technology Acceptance Model (TAM) and the extended TAM and used to examine the antecedents and consequences.

The main theoretical underpinning discussed in this study to explain users' response to learning technologies deployed in teaching by other researchers include the TAM (Davis 1989). Core TAM constructs include perceived usefulness, perceived ease of use, attitude and self-efficacy.

This theoretical approach was not expressly developed to understand the use and perceived usefulness of videos for teaching. Our study does, however, look at the results through this theoretical lens when examining the use of purpose-made videos that were delivered using Internet technologies to replace traditional in-lab teaching.

All learning modules of our study were deployed through the D2L (Desire2Learn) Brightspace Learning Management System (LMS). Technology can have a multi-edged sword for online learning. It assumes that the user has the required technology that is current, suitably fast, reliable, and sufficient in amount or size. These include processors, random-access memory (RAM) cards, video and graphics cards, a monitor, a multi-button mouse, and Internet access. But this is not the case for everyone, and an uneven field may be created. In addition, a suitable workspace where the student can focus is needed. Cheng (2010) refers to this as the space barrier.

Due to the COVID-19 pandemic and abrupt implementation of emergency remote teaching, many students were unprepared for the rapid technological expectations. With the world shifting to an online environment suddenly and simultaneously, a shortage of technology was created for computers with fast processors and suitable amounts of RAM, modems, monitors, cameras, microphones, and other technology. Since some international students were required to return to their home countries many time zones away, not all students were able to fully take advantage of synchronous learning. Dror (2009) indicated that, "Students learn more efficiently with control over the procedure, something that challenges them, and something that makes them commit".

A question asked on the survey instrument to the students was how they used the videos and not how they enjoyed the videos. This study interprets the higher use, i.e. watching the videos multiple times and watching them both in class and again at home, to suggest their usefulness. Chen (2012) studied "The possibility of controlling individual speed". High use itself may not necessarily be attributed to enjoyment. Asynchronous online learning can simply equate to the requirement for self-study.

"Students demonstrate increased interest in the subject at hand and learning is enhanced when instruction is integrated with multimedia tools" (Schacter,1999; Ruiz et al.,2006). YouTube videos have become pervasive, especially for Generation-Z users. Doo Young Lee's 2013 study User Acceptance of YouTube for Procedural Learning: An Extension of the Technology Acceptance Model examined perceived usefulness and perceived ease of use, as they apply to YouTube videos. The research considers videos used for procedural learning. Doo examines five added constructs: user satisfaction, task-technology fit, content richness, vividness, and YouTube self-efficacy. The study's author implores that those two key constructs work cohesively with the simplified TAM mechanism. Both perceived usefulness and perceived ease of use generates the user acceptance of learning on the YouTube platform (Doo 2013). Furthermore, Doo states that "content richness is operationally defined here as the abundance of learning resources that users can access to enrich their learning activity" (Doo 2013). Although YouTube primarily serves as an entertainment platform, Doo suggests that this video sharing company needs to promote its educational value and users need to leverage the channel as a valuable resource for instruction and procedural learning (Doo 2013).

Emergency Remote Learning

In March of 2020, the world was immediately and substantially overturned by the COVID-19 global pandemic. In-person teaching and in-person learning were immediately suspended. Instructors were forced into emergency remote teaching and were required to pivot quickly to deliver content remotely using both synchronous and asynchronous online strategies. The following table shows the pre-pandemic situation and changes made for emergency remote teaching during the pandemic for the course of this study, GCM750 (Introduction to 3D Printing).

To overcome the challenges posed during remote teaching, several changes were made to the course. When time is of the essence, the immediate source of

Table 2

Pre- Pandemic and During Pandemics Course Changes

Pre-pandemic	During pandemic
Lectures delivered live, not recorded.	Most lectures were delivered via pre-recorded Zoom videos.
Software demos done live in the lab, not recorded.	Software use taught using purpose-made videos. YouTube videos carefully prescreened and provided as voluntary supplementary learning material.
Students take a field trip and write a research paper.	Field trip research assignment done through attendance at an international online conference.
Students have 24/7 access to modern on campus computer labs supported by hardware and software technicians.	Students must download, install highly specialized technical software on their own computer. Technical support for 100 students online becomes the responsibility of the instructor and teaching assistants. This includes assisting students in installing and implementing software on student's home computers, all done remotely.
Students gain hands-on use of 3D printers and use 3D scanners in the lab.	Some in-lab modules eliminated, 3D printing and 3D scanning replaced with more emphasis on learning software.

teaching assistance is often either YouTube or Lynda.com/LinkedIn learning videos. YouTube videos broadly address many different objectives and channels including entertainment, marketing, product demos and education. Those that have an educational focus may not follow standards or best practices to be useful as formal instruction in post-secondary education. Many YouTube videos are made by "YouTubers", whose main motivation is to attract viewers so they can generate clicks, likes and a cash flow. Though the main content may be educational, they may also be more self-promotional and may also include inappropriate content. Some of these videos might still be used as an easy and quick solution (or last resort) when no other options are available or in the absence of a budget or sufficient lead time to create purpose-made videos.

Purpose-Made Videos

Highly technical topics like CAD software (Computer-Assisted Design) typically have a steep learning curve for a beginner user. Teaching CAD software online can add an additional layer of complexity to an already challenging task.

Special COVID-19 pandemic funding was obtained to employ Teaching Assistants (TAs) to assist the instructor in the development of purpose-made videos. Along with TAs, the instructor-led team spent the winter break prior to the start of the winter semester researching, scripting, recording, and editing purpose-made videos that deliver on the learning objectives of the in-lab course curriculum while under the pandemic lockdown.

One of the best practices for videos made for educational use is to "chunk" content down to learning objects that are 5-15 minutes long. The best videos to teach CAD software use include detailed step-by-step instructions, demonstrations, subtitles, and transcripts that are tightly focused on a single or a few focused tasks. Emphasis on good video and sound quality is paramount. A thematic approach can be employed, where themes are closely adhered to.

Videos allow students to pace their learning, they can fast-forward, rewind, and watch specific "chunks" as many times as necessary. Such videos can target only those key learning concepts required to complete projects, thereby managing and fast-tracking learning. Another benefit includes time shifting as students can watch during their optimum peak study times. "The option to seek or overtake a specific portion of the video, and the capability to watch a particular portion again if needed" (Zhang et al. 2006) provide a useful self-paced instructional context where reduced levels of embarrassment and anxiety allow learners to be comfortable enough to learn new content" (Pendell et al. 2013). Zhang posits that "a major assumption of the cognitive learning model is that a learner's attention is limited and therefore selective" (2006). Chunking allows viewers selectivity.

Another key aspect of consideration was that students who normally used university in-lab computers with pre-installed software, serviced by a team of technical experts, were forced to use less desirable (usually older, less powerful) computers and, in many cases, slower Internet access at their homes. Often, students shared crowded home conditions with family members. Other students had returned to their overseas homes because of the pandemic and were faced with incompatible time zones as well as with Internet access issues.

Research Design

This study was designed to explore the following research questions:

- What overall challenges were experienced by undergraduate students enrolled in the 3D printing elective course during the remote learning period?
- How did students adapt to a heavily kinesthetic course in a virtual online environment?
- What were the challenges and limitations of a hands-on course being taught online?
- How useful were the specific course-made videos introducing various softwares that were part of the academic curriculum?

To further explore these questions, a survey was designed and implemented (see Appendix A). These 50 questions included the collection of basic demographic information, Likert scales ranging from 1-5 (i.e. Highly Agree to Highly Disagree), multiple choice, and an open-ended question. There were 40 students out of the 89 who completed the course and responded to the survey. They were asked to provide their gender, year of study, a domestic or international student, and was their place of residence outside of Ontario, Canada. The Google Forms survey was conducted within a 20-minute period during the last synchronous online lecture. A disclaimer introduced the survey revealing student anonymity and confidentiality.

Several weeks prior to the end of the academic year, an announcement was made about a voluntary survey that would be conducted during the last synchronous online lecture. This announcement was communicated through electronic mail and asynchronous pre-recorded lectures. Within those mediums, the announcement briefly described the survey design as well as the reassurance of confidentiality and anonymity.

Students of all years were recruited in order to assess the perspective of students with a wider range of academic backgrounds, remote situations, and interests. Most participants were familiar with at least some form of online learning prior to the COVID-19 pandemic (example: supplementary videos, online modules, or other virtual learning methods).

Table 3
Survey Sections

Section 1	General/Background Information
Section 2	Computer Technology Background/ Environment
Section 3	Video Resources for Lectures (PRE-COVID)
Section 4	Video Resources for GCM750 Lectures (Winter 2021)
Section 5	Video Resources for GCM750 Labs (Winter 2021)
Section 6	Locus of Adoption
Section 7	Comparing Course-made Videos to YouTube Videos

The survey used in the study included fifty questions, broken down into seven sections. Most of the survey questions investigated how students adapted to a virtual academic environment. The methods used for face-to-face instruction were hands-on and tactile. The drastic shift to a remote setting necessitated further inquiry. Questioning students about learning 3D printing software in a virtual environment helped gauge the effectiveness of retaining purpose-made video content.

Data Collection

The aggregated data was stored as a Google Forms document. Prior to implementing the survey to students, the survey draft was submitted to the university's Research Ethics Board (REB) for consideration. Upon a brief review, the REB responded that the survey did not mandate an ethics review as it merely posed a research question and intended to draw generalizable insights whilst assessing the pedagogy in the online 3D printing elective course. After the exemption from the REB, the survey was finalized and released to the students for data collection.

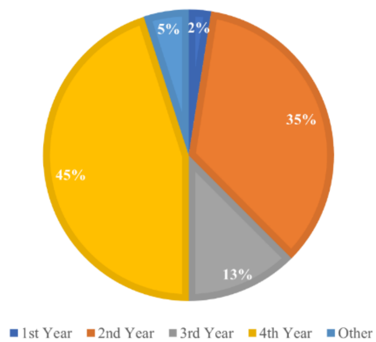
Results and Analysis

To generate a deeper understanding of the raw data, three main demographic variables were used to narrow down the completed results. The respondents' gender, year of study, and private space versus shared space was filtered to provide specific results. The survey consisted of N=12 males, N=27 females, and N=1 student that preferred to leave their gender anonymous. Approximately 68% of total respondents were females which may have influenced the final survey results as well as data analysis. Moreover, the breakdown by the year of study (Figure 1) yielded:

- First-year student N=1
- Second-year students N=14
- Third-year students N=5
- Fourth-year students N=18
- Students who identified as "Other"

Figure 1

Respondents



Survey Part 1 Question 2. What is the year of study in your current program? A pie chart breakdown of respondents by their indicated year of study were as follows: The color-coded system sorts 1st year students as dark blue (N=1; 2%), 2nd year students as orange (N=14; 35%), 3rd year students as grey (N=5; 13%); 4th year students as yellow (N=18; 45%); and students who identified as a different year of study in light blue (N=2; 5%).

This indicated that the majority of the demographic were fourth-year students (45%) and second-year students (35%), which may have impacted the results of the data analysis.

In another question, students were surveyed about their off campus (at home) study space. N=11 respondents (27.5%) had to share their workspace with someone throughout the academic semester whereas N=29 respondents (72.5%) had their own private room and/or space to work during the school year.

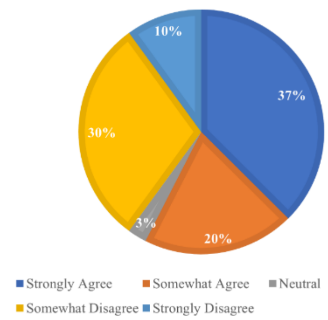
Internet Connectivity Capabilities

One of the largest varying factors in virtual education was internet connectivity. Responding to two questions from the conducted survey, the pie charts in Figures 4a and 4b compared the responses to the Likert scale prompts "I have the correct computer technology for remote studying (i.e. fast processor, three-button mouse, good Internet connectivity)" and "This semester I've experienced Internet connection problems," respectively. The latter prompt referenced a unique Likert scale ranging from Regularly to Never, whereas the first prompt ranged from Strongly Agree to Strongly Disagree.

Figure 2a

Breakdown of Respondents

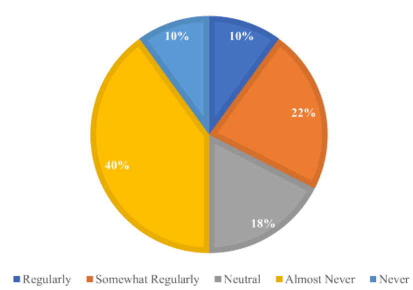
Survey Part 2 Question 4. I have the correct computer technology for remote studying (i.e. fast processer, three-button mouse, good internet connectivity)



This pie chart illustrates the total percentage breakdown of the number of respondents (N=40) that own the correct computer technology for this course. The color-coded system indicates that Strongly Agree (N=15) is coded in dark blue; Somewhat Agree (N=8) is coded in orange; Neutral (N=1) is coded in grey; Somewhat Disagree (N=12) is coded in yellow; and Strongly Disagree (N=4) is coded in light blue.

Figure 2b

Internet Issues



Survey Part 2 Question 8. This semester I have experienced internet connection problems

This pie chart depicting the regularity and severity of internet issues throughout the academic semester. The Likert scale uses a color-coded system to identify the following: Regularly (N=4) as dark blue; Somewhat Regularly (N=9) as orange; Neutral (N=7) as grey; Almost Never (N=16) as yellow; and Never (N=4) as light blue.

The graphed data indicated that most students that experienced somewhat regular internet issues (N=4) also somewhat had the correct technology for their online education. In contrast, the largest portion of the chart showed that 11 respondents rarely experienced any internet issues and either somewhat disagreed (N=6) or strongly disagreed (N=5) that they owned the appropriate technology for this academic course.

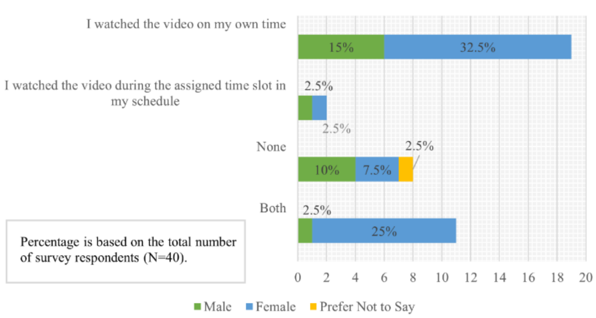
Cumulatively, 16 out of 40 possible respondents (40%) either somewhat or strongly disagreed that they owned the correct equipment for the academic semester. 23 out of 40 respondents (57.5%), however, indicated that they owned the appropriate computer technology and either strongly or somewhat agreed to their claim. Only one respondent remained neutral. In terms of internet connectivity issues, 13 respondents either regularly (N=4) or somewhat regularly (N=9) experienced problems. Over half of the respondents (N=20) either rarely (N=16) or never (N=4) experienced internet issues. Seven respondents remained neutral.

The Students' Use of Pre-Recorded Lectures

A stacked bar chart of student responses (N=40) to the question "If there were pre-recorded lectures, did you watch the video during the assigned time slot in your schedule or on your own time?" is shown below.

Figure 3

Demographics Filter



Survey Part 4 Question 3. If there were pre-recorded lectures, did you watch the video during the assigned time slot in your schedule or on your own time?

The demographic filter applied is gender-based and male (M) respondents are color-coded green, female (F) respondents are color-coded blue, and prefer not to say are color-coded yellow. The numeric scale along the x-axis provides the quantity of respondents.

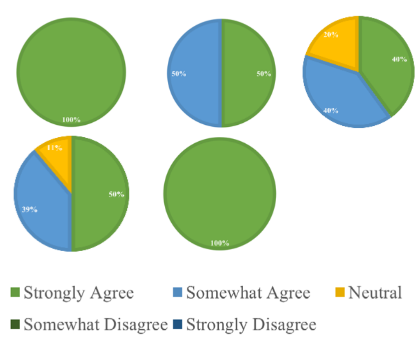
This data result not only suggests the diligence of the female students in this course while in a virtual learning environment, but also the active participation within the course that was positively reflected in their learning. Male respondents, however, were more prone to resist academic workload as a quarter of the total male respondents (N=4) watched the pre-recorded videos neither on their own time nor during the assigned time slot in their academic schedule. Half of the male respondents (N=6) preferred to watch pre-recorded lectures on their own time and established their own learning pace. About two thirds of the respondents (N=19) watched the videos consistently on their own time.

Efficacy of Customized Videos

As a result of students being responsible for their own learning, customized videos were created that targeted learning software used in 3D CAD design. Respondents were asked "I am able to absorb 3D print modeling better because the customized videos allowed me to go at my own pace through the course materials (notes, lectures)." The following series of pie charts display student responses (N=40) to the Likert-scale in Figure 4 below.

Figure 4

Year of Study Filter



Survey Part 1 Question 2. What is the year of study in your current program?

The year of study filter is applied and color-coded as follows: strongly agree in light green, somewhat agree in light blue, neutral in yellow, somewhat disagree in dark green, and strongly disagree in dark blue. Each pie chart is labeled under the respondents' year of study and a percentage is displayed under the given year. The total of respondents from each year is as follows: first year (N=1), second year (N=14), third year (N=5), fourth year (N=18), and another year of study (N=2).

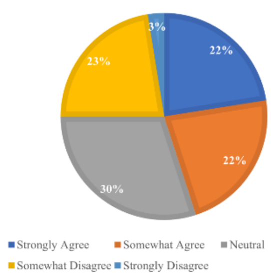
The purpose-made videos created by the teaching assistants proved to be extremely useful and beneficial for the students and the results are evident in Figure 4. The video topics covered various 3D print modeling CAD softwares and offered step by step tutorials on how to use the basic functions and tools within a given program's interface. With zero students negatively responding towards the creation and integration of customized videos, most students (N=21) strongly agreed that the tutorial videos were useful for their learning. As previously mentioned, the larger academic demographic consisted of second-year (N=14) and fourth-year (N=18) students. These results yield the majority demographic of this response where second-year students (N=7) and fourth-year students (N=9) strongly agreed that learning at their own pace was beneficial to the absorption of course material.

Continuation of Online Education

Along with the thematic videos to assist the students' virtual learning journey, a survey prompt asked about the future academic direction in a post-pandemic situation. The prompt "The videos made for this course could be used to replace regular in-lab instruction" yielded the following responses in Figure 5 below.

Figure 5

Breakdown of the Segments



Survey Part 7b question 5. The videos made for this course could be used to replace regular in-lab instruction.

This is a pie chart responding to the Likert scale prompt mentioned above and uses a color-coded system to break down the segments. Out of the total responses (N=40), dark blue indicates Strongly Agree (N=9); orange indicates Somewhat Agree (N=9); grey indicates Neutral (N=12); yellow indicates Somewhat Disagree (N=9); and light blue indicates Strongly Disagree (N=1).

Throughout the academic semester, students were offered numerous resources of additional help. This prevailed through a public discussion board on the LMS D2L Brightspace, consistent email contact between the instructor as well as teaching assistants, and virtual open labs where students had the liberty to log in to ask questions and receive clarifications. The availability of resources may have affected the survey's results and impacted the learning journey of the students.

The final section of the survey included a single open-ended question with the following prompt: "Any additional comments/suggestions you would like to mention? Please note that these responses are anonymous." 10 respondents chose to share their suggestions where the majority (N=6) showed appreciation for the effort in creating course-target videos while the remainder (N=4) offered opportunities for improvement.

Discussion

A pandemic such as COVID-19 is a very sudden and unanticipated event, leaving both students and instructors little time to plan fully and effectively. For example, if students in this course could predict that they would need a faster, more robust computer with better internet connectivity, they might have had time to plan and invest in new technology, or possibly waited to take this hands-on course when in-class teaching and learning resumed. Without enough lead time, and due to the world going online, there was a global shortage for technology. Although the university offered loaner laptop computers and high-speed internet devices at no cost, few students took advantage of such technology.

Purpose-made videos were produced to support the three major assignments. The survey results showed that students found these videos very useful. However, on the final assignment no purpose-made videos were produced. As a result, one student's survey response indicated: "I was more lost on the Cura assignment and found that there was not enough tutorial or explanation on the processes required for that assignment. The other assignments I felt were explained well enough and/or the videos supplemented the information I needed to complete them." This verifies the efficacy of the purpose-made videos.

Not only was the course delivered under emergency remote teaching with short timelines, but the survey and research planning for this paper was also conceived and implemented on short notice.

Conclusion

This study examined how students adapted to an online learning environment for an elective course that is strongly application-based and requires tactical knowledge which is taught in-person.

Although many studies suggest that the TAM's main constructs measure the user's adoption of virtual learning, the purpose-made videos created by the TAs were time consuming to produce and, therefore, were costly. Budget restraints will often result in a lack of such useful teaching materials. This model extends Davis' (1989) findings regarding understanding the use and perceived usefulness of videos for teaching through a theoretical framework.

Survey respondents in this study demonstrated that despite the harshly abrupt online conditions, additional resources in the form of purpose-made videos aided the students' learning journey. Video sharing platforms like YouTube and LinkedIn Learning/Lynda.com only enhanced the quality of online education and further grasped Davis' (1989) TAM theoretical approach.

At the time of this study, decision makers were contemplating and debating whether the Fall term of 2021 would be a full return to in-class learning, a partial return, or a continuation of 100% online learning. This offers the opportunity to continue to study the effects of choices and important lessons learned.

Recommendation for Further Research

A replication of this study under no emergency remote teaching conditions; where there is not a short timeline for conducting the study; and to establish a control group in addition to the study group.

Acknowledgements

The first author of this study is also the instructor of the course that is the subject of this study. The second author was a Teaching Assistant for the course that is the subject of this study.

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Appendix A: Student Questionnaire

Part 1: General/Background Information

1. What is your gender?
   - Female
   - Male
   - Prefer not to say
   - Other
2. What is the year of study in your current program?
   - 1
   - 2
   - 3
   - 4
   - Other
3. Are you a domestic student or international student (US included)?
   - Domestic Student
   - International Student
4. Are you currently residing outside of Ontario?
   - Yes
   - No

Part 2: Computer Technology Background and Environment

1. This semester I am:
   - Residing at home
   - Not residing at home (i.e. campus, apartment)
2. This semester I have:

- My own room/space to study
- I have to share space with a family member or roommate

3. I have younger pre-postsecondary age kids at my home.
   - Yes
   - No
   - Other
4. I have the correct computer technology for remote studying (i.e. fast processer, three-button mouse, good internet connectivity).

Strongly Agree	1	2	3	4	5	Strongly Disagree

5. This semester I have:
   - My own computer
   - I have to share a computer
   - I have a loaner computer form the university
6. This semester I borrowed an internet dongle from the university.
   - Yes
   - No
7. This semester I accessed the internet for my studies by visiting a public space that offered WiFi.
   - Yes
   - No
8. This semester I have experienced internet connection problems.

Strongly Agree	1	2	3	4	5	Strongly Disagree

Part 3: Video Resources for Lecture Classes Pre-COVID-19 (prior to March 2020)

1. How many courses had used videos to teach in the lectures?
   - All
   - Most
   - Some
   - None
2. If there were pre-recorded lectures, I was able to absorb the content better because I could go at my own pace through the course materials (notes, lectures).
   - Strongly agree
   - Somewhat agree
   - Neither agree not disagree
   - Somewhat disagree
   - Strongly disagree
   - N/A
3. If there were pre-recorded lectures, how frequently did you re-watch the videos?
   - 5
   - 4
   - 3
   - 2
   - 1
   - Never
   - N/A
4. If there were pre-recorded lectures, did you watch the video during the assigned time slot in your schedule or on your own time?
   - I watched the video during the assigned time slot in my schedule
   - I watched the video on my own time
   - Both
   - None
5. If there were YouTube videos, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A
6. If there were Lynda / LinkedIn Learning videos, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A
7. If there were videos created specifically for the course, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A
8. If there were other videos (for example, from the textbook publisher, from an industry supplier of hardware or consumable materials), how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A

Part 4: Video Resources for GCM750 Lecture Classes (in this current semester of Winter 2021)

1. I am able to absorb the content better because I can go at my own pace through the course materials (notes, lectures).

Strongly Agree	1	2	3	4	5	Strongly Disagree

2. For the pre-recorded lectures, how frequently did you re-watch the videos?
   - 5
   - 4
   - 3
   - 2
   - 1
   - Never
3. For the pre-recorded lectures, did you watch the video during the assigned time slot in your schedule or on your own time?
   - I watched the video during the assigned time slot in my schedule
   - I watched the video on my own time
   - Both
   - None
4. For YouTube videos, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - I did not watch any YouTube videos
5. For Lynda / LinkedIn Learning videos, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - I did not watch any Lynda/LinkedIn Learning videos
6. For videos created specifically for the course, how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - I did not watch any videos created specifically for the course
7. For other videos (for example, from the textbook publisher, from an industry supplier of hardware or consumable materials), how useful were they?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A

Part 5: Video Resources for GCM750 Laboratory Classes (in this current semester of Winter 2021)

1. I am able to absorb 3D print modeling better because the customized videos allowed me to go at my own pace through the course materials (notes, lectures).

Strongly Agree	1	2	3	4	5	Strongly Disagree

2. How useful were the YouTube videos used to supplement the topic?

Very Useful	1	2	3	4	5	Very Not Useful

3. How useful were the Lynda / LinkedIn Learning videos used to supplement the topic?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A
4. How useful were the other videos to supplement the topic (for example, from the textbook publisher, from an industry supplier of hardware or consumable materials)?
   - Very Useful
   - Somewhat Useful
   - Neither Useful nor Not Useful
   - Somewhat Not Useful
   - Very Not Useful
   - N/A

Part 6: Locus of Adoption

1. The 3D print online lab classes feel more detached and impersonal compared to an in-person lab environment.

Strongly Agree	1	2	3	4	5	Strongly Disagree

2. I would prefer to be learning 3D print modeling with other students in person.

Strongly Agree	1	2	3	4	5	Strongly Disagree

3. I regularly felt in-step with learning the 3D modeling software.

Strongly Agree	1	2	3	4	5	Strongly Disagree

4. In the question above, if you selected Strongly Disagree (5) or Somewhat Disagree (4), why did you feel lost or behind in learning the 3D modeling software?

5. Learning in a remote environment, I feel like I'm absorbing the lab material the same way I might if I was in an in-person lab.

Strongly Agree	1	2	3	4	5	Strongly Disagree

6. I prefer pre-recorded lectures over live lectures.

Strongly Agree	1	2	3	4	5	Strongly Disagree

Part 7a: Comparing Course Made Videos to YouTube Videos

1. How many times, on average (including class viewing), did you watch each video?
   a. TinkerCAD
      - 0
      - 1-4
      - 5-7
      - 8-10
   b. ZBrushCoreMini
      - 0
      - 1-4
      - 5-7
      - 8-10
   c. Fusion 360
      - 0
      - 1-4
      - 5-7
      - 8-10

Part 7b: About the videos made for the GCM750 course:

1. The QUANTITY of videos made for this course was appropriate.

Strongly Agree	1	2	3	4	5	Strongly Disagree

2. The QUALITY of videos made for this course was appropriate.

Strongly Agree	1	2	3	4	5	Strongly Disagree

3. The videos made for this course specifically targeted the concepts and procedures I needed to complete my assignments.

Strongly Agree	1	2	3	4	5	Strongly Disagree

4. The videos made for this course made my learning easier than regular in-lab instruction.

Strongly Agree	1	2	3	4	5	Strongly Disagree

5. The videos made for this course could be used to replace regular in-lab instruction.

Strongly Agree	1	2	3	4	5	Strongly Disagree

6. The videos made for this course allowed me to rely less on asking for help.

Strongly Agree	1	2	3	4	5	Strongly Disagree

Part 7c: About the YouTube videos for educational purposes:

1. I generally enjoy using YouTube videos for educational videos.

Strongly Agree	1	2	3	4	5	Strongly Disagree

2. The QUANTITY of YouTube videos available are appropriate for me to learn the topics of this course.

Strongly Agree	1	2	3	4	5	Strongly Disagree

3. The QUALITY of YouTube videos available are appropriate for me to learn the topics of this course.

Strongly Agree	1	2	3	4	5	Strongly Disagree

4. YouTube videos available appropriately target the concepts and procedures I need to complete my class assignments for this course.

Strongly Agree	1	2	3	4	5	Strongly Disagree

5. The course-suggested YouTube videos were still necessary to supplement the videos created for this course.

Strongly Agree	1	2	3	4	5	Strongly Disagree

Open-Ended Question

1. Any additional comments/suggestions you would like to mention? Please note that these responses are anonymous.

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2. Juried articles are submitted to the editor and are distributed to jurors for acceptance/rejection. Juried articles are typically reviews of literature, state-of-the-art technical articles, and other nonempirical papers. Jurors make comments to the author, and the author makes required changes. The decision of the review board is final.

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4. Student articles are submitted by GCEA members and are accepted/rejected by the editor. These articles are not submitted to a panel of jurors. The editor's decision is final. Please be aware that poorly written student papers will be rejected or returned for editing.

5. Book reviews deemed worthy for consideration by the editor will be reviewed by the editor. Book reviews shall be limited to 1500 words. The editor's decision is final.

Eligibility for Publication

» Members of the Graphic Communications Education Association, or students of GCEA members, may publish in the Visual Communications Journal.

» Those wishing to publish should join GCEA before submitting their paper for review.

Audience

» Write articles for educators, students, industry representatives, and others interested in graphic arts, graphic communications, graphic design, commercial art, communications technology, visual communications technology, printing, photography, or digital media. Present implications for the audience in the article.

Manuscript Form and Style

» Manuscripts should conform to APA 7th edition style

» Papers must be submitted in Microsoft Word format.

» The approximate location of all tables and figures should be clearly indicated in the text.

» Author's name, highest degree, affiliation, title, abstract and keywords shall be listed on the first page only. Article text should begin on the second page.

» Articles should be proofread carefully before submitting. Articles with severe spelling and grammatical issues shall be rejected.

Figures (Graphics)

» All figures should contain a number and caption conforming to APA 7th edition style

» Screen captures should be as large as possible.

» Photos should be 300 ppi to span one column (3-inches) or 2 columns (6.5-inches).

» Line art should be in a vector format.

Tables

» Tables shall conform to APA 7th edition style

» Tables will be formatted by the designer to fit in one column (3″ wide) or across two columns (6.5″ wide).

Publication and Format

» The Visual Communications Journal is published and distributed twice a year, in the spring and in the fall. Each article of the Journal is published online at www.GCEAonline.org.

Notice of Limitation

» Articles submitted to the Journal cannot be submitted to other publications while under review. Articles published in other copyrighted publications may not be submitted to the Journal, and articles published by the Journal may not be published in other publications without written permission of the Journal.

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